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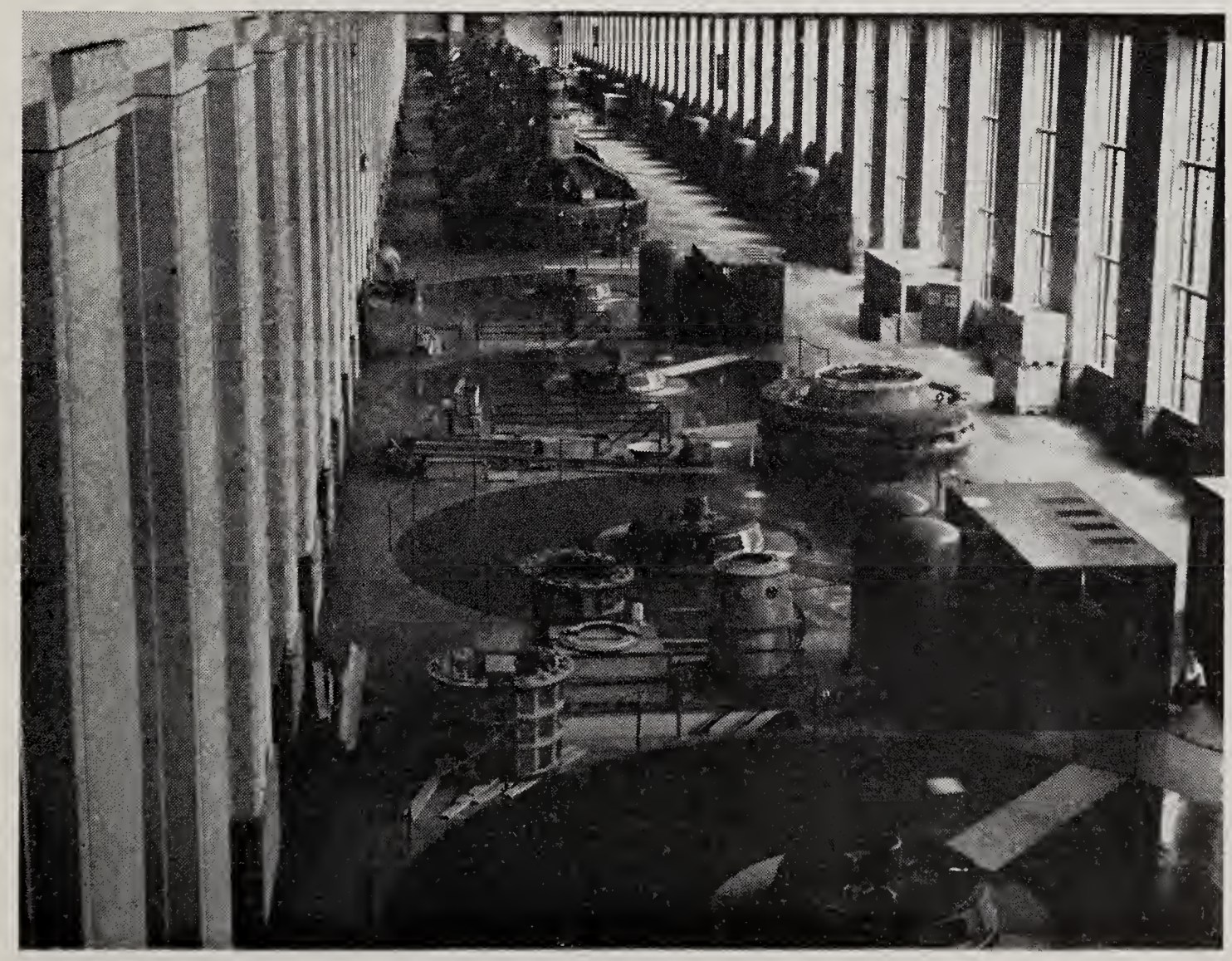
CONTENTS

	Page
I. The Widening of Economic Choice	1
Region rich but exploited	2
Expanding control over resources	3
Evidences of progress	6
Benefits extend beyond region	7
II. The River in Use	9
FPC reviews multiple-purpose allocation	10
Lowest benefits outweigh highest costs	11
Waterway traffic trends upward	13
Distribution patterns changed	14
Water control operations	15
Flood damage averted	15
Watauga Dam completed	16
Hales Bar pool level raised	17
Steam plant construction started	18
Management of reservoir lands	19
Recreation development on lakes	19
Fish and waterfowl attract sportsmen	20
Land used in many ways	22
Malaria incidence remains low	22
Progress in stream sanitation	24
Purchases of land	25
Sales of TVA lands and villages	25
III. Progress on the Land	27
The region makes progress	28
Fertilizers for agriculture	28
TVA and fertilizer technology	29
Munitions	29
Phases of development	29
Phosphate technology	30
Nitrogen processes	31
Phosphate-nitrogen processes	32
Production of fertilizer materials	32
TVA developments aid industry	33
Fertilizers and soil management	34
Controlled investigations	34
Test-demonstrations aid farmers	35
Fertilizer payment plan changed	36
Number of test-demonstrations	37
Farm cooperatives help	37

III. Progress on the Land—Continued Page
Measurement of test-demonstration results 38
Comparisons for seven valley States 40
Trends in valley counties 41
Mechanical measures for soil conservation 41
The forest resources 42
Fire protection aids forest development 42
Forest management demonstrations 43
Forest research and experimentation 44
Reforestation 45
Facts made known 45
Minerals investigations 45
IV. More Power for More People 47
The fiscal year in summary 48
Power production 48
Source and disposition of power 49
Fuel plant generation 49
Generating capacity expanded 50
Power from Cumberland River dams 50
Additional capacity on the way 51
Operating costs reduced 51
Transmission system improved 52
The returns from power 53
How earnings are used 53
Local distribution of TVA power 54
Electric service extended to 120,000 consumers 55
Low rates—greater use—more revenues 56
Rural service expands rapidly 57
Financing improvements and expansions 57
Electrical development 58
Financial results are good 59
V. Personnel and Management 61
Training activities 61
Labor relations 62
Negotiations on wage rates 62
Joint cooperative committees 63
Employee safety 63
Procurement 64

When TVA assumed control of Wilson Dam at Muscle Shoals, Ala., in 1933, its powerhouse had an installed capacity of 184,000 kw. Today (lower photo) its capacity is 335,200 kw and four units totaling 100,800 kw are under construction. At the year's close the entire system had an installed capacity of nearly 2,800,000 kw. Several steps were taken during the year to effect economies in the system's operation. A helicopter now is used to patrol the 7,000 miles of major power transmission lines heretofore patrolled on foot, cutting patrolling costs in half.



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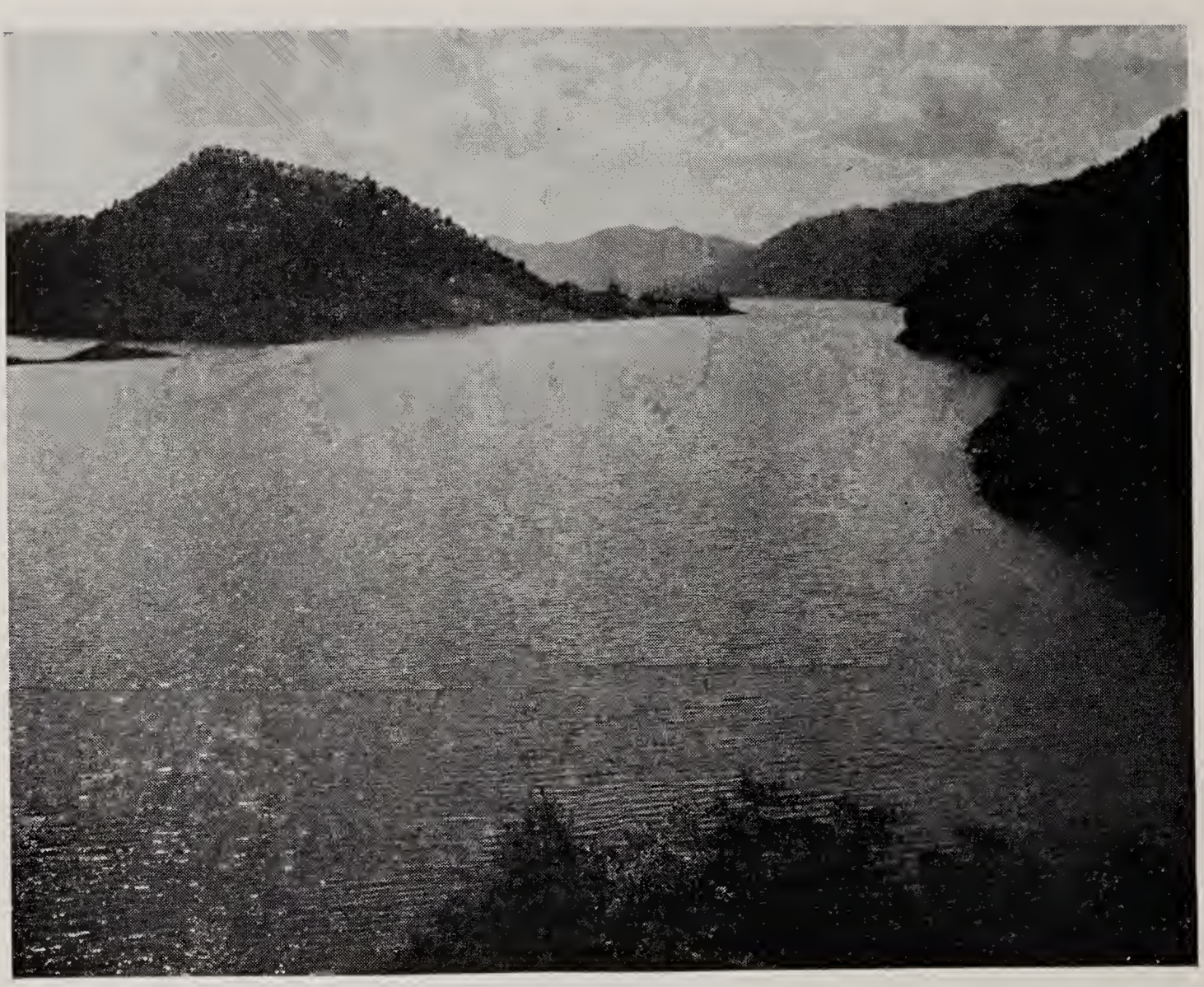
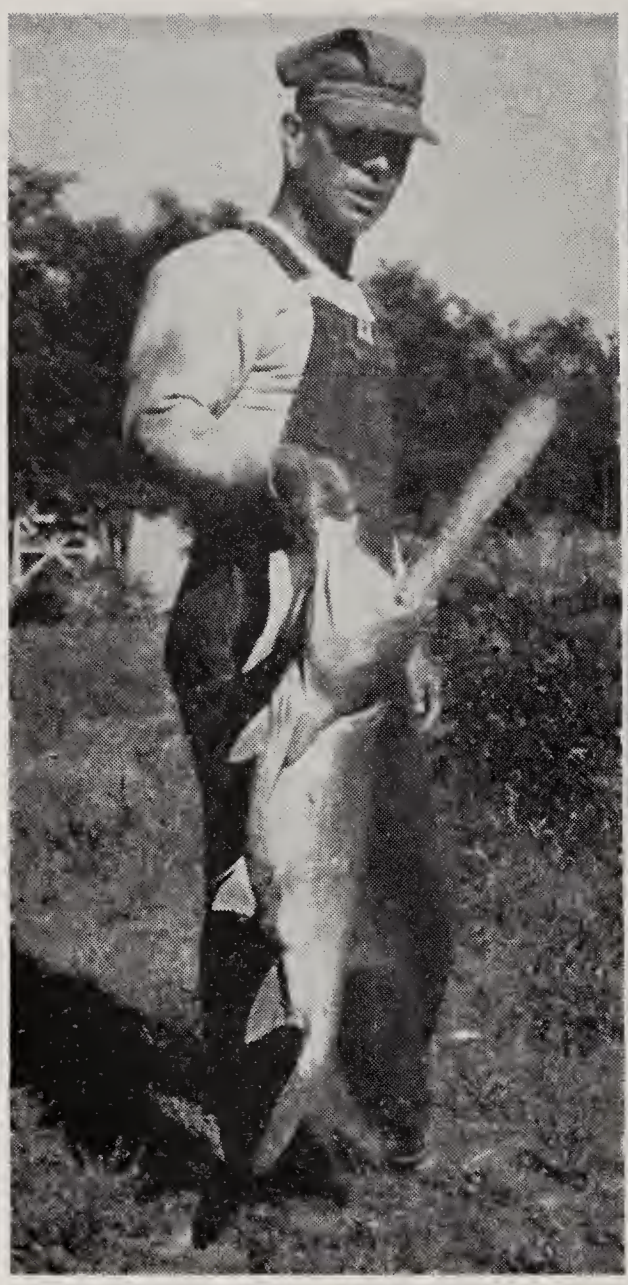
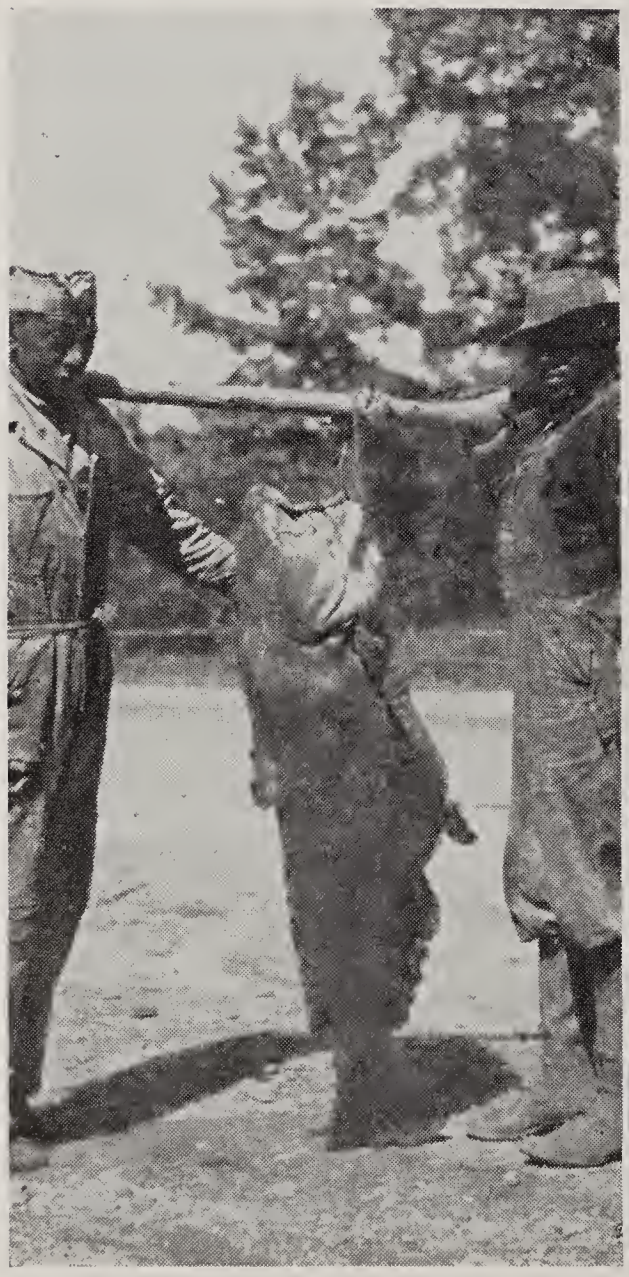


Watauga Dam, in east Tennessee, is the seventeenth and most recent to be completed by TVA. It is a multiple-purpose dam, serving the interests of flood control, navigation, and power development. The reservoir (top) is one of the most scenic in the system, with a total volume of 678,800 acre-feet and useful storage of 627,000 acre-feet. Construction of South Holston Dam (lower photo), also in east Tennessee, progressed rapidly during the year. South Holston also will provide considerable flood storage; completion is scheduled for late 1950.

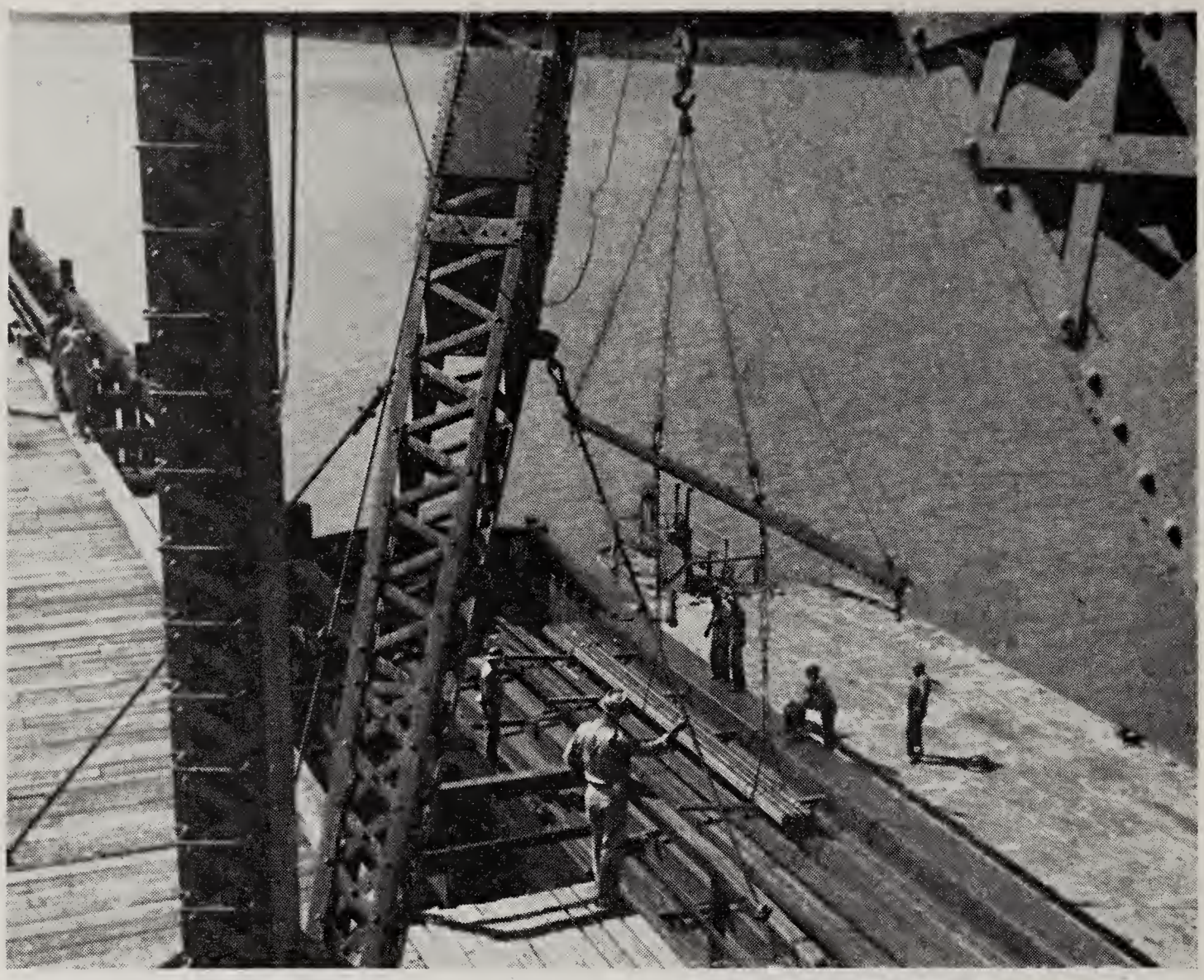
Less than a month after the close of the year, the millionth consumer of TVA power was being served. He is Chester Williams, farmer, living near Humboldt, Tenn. He receives power through the Gibson County Electric Membership Corporation, one of 144 municipal or cooperative systems buying TVA power at wholesale. Lower photo shows Mrs. Williams lighting old range for the last time. Investment of locally owned systems has risen to nearly $250,000,000. They built 17,200 miles of rural lines during the year, servicing 75,000 farms.



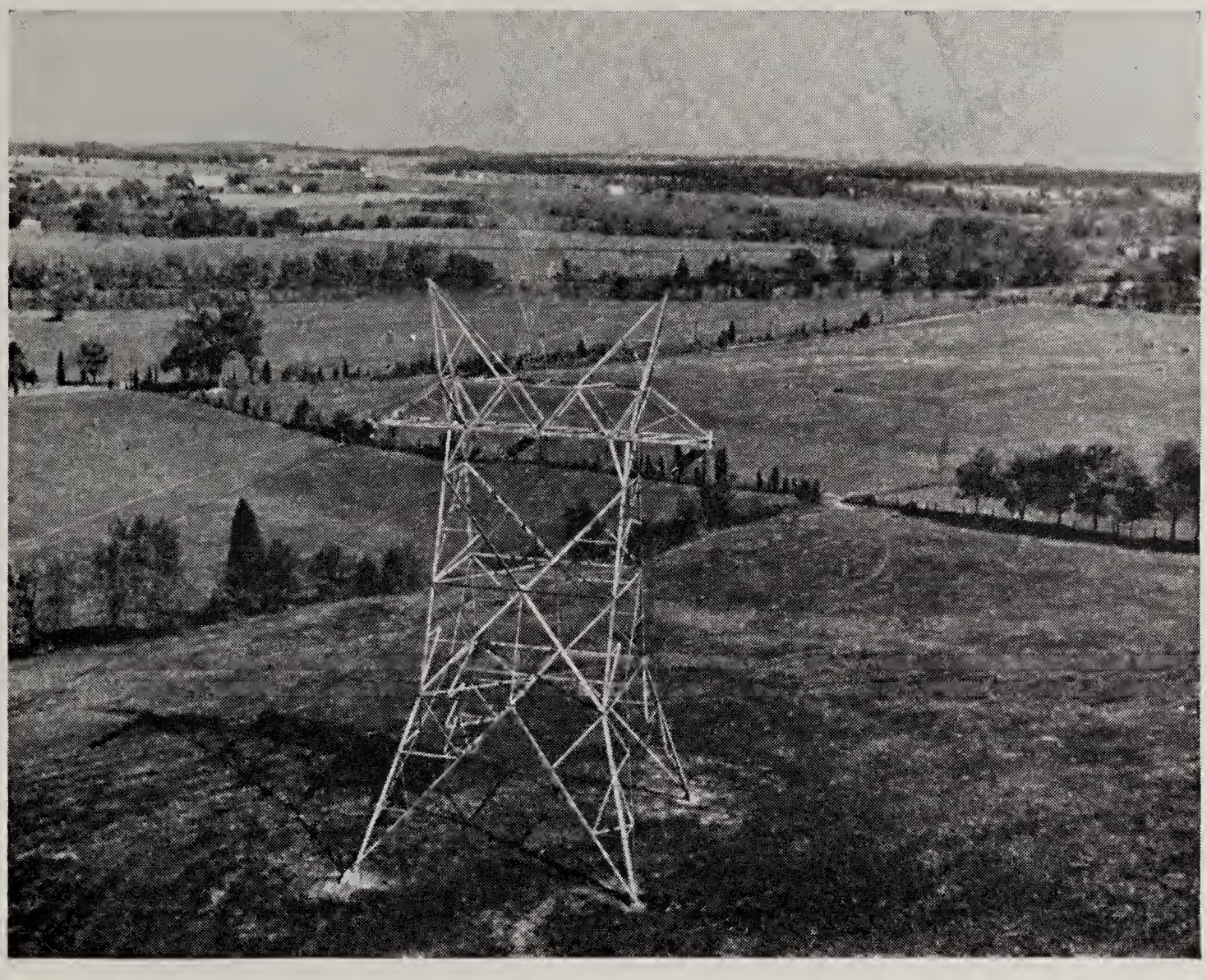
Although sport fishing in TVA lakes is of greater importance to the Valley economically, commercial fishing brings a sizable income to a number of residents. Last year 1,500,000 pounds of fish were caught for the commercial market, giving the fishermen a gross income of $369,520. Mussel fishing, too (upper right), yields an income—an average of about $500,000 a year. The shells are in demand by the button industry. Development of the Valley as a wintering ground for wildfowl brings added recreation to many thousands.



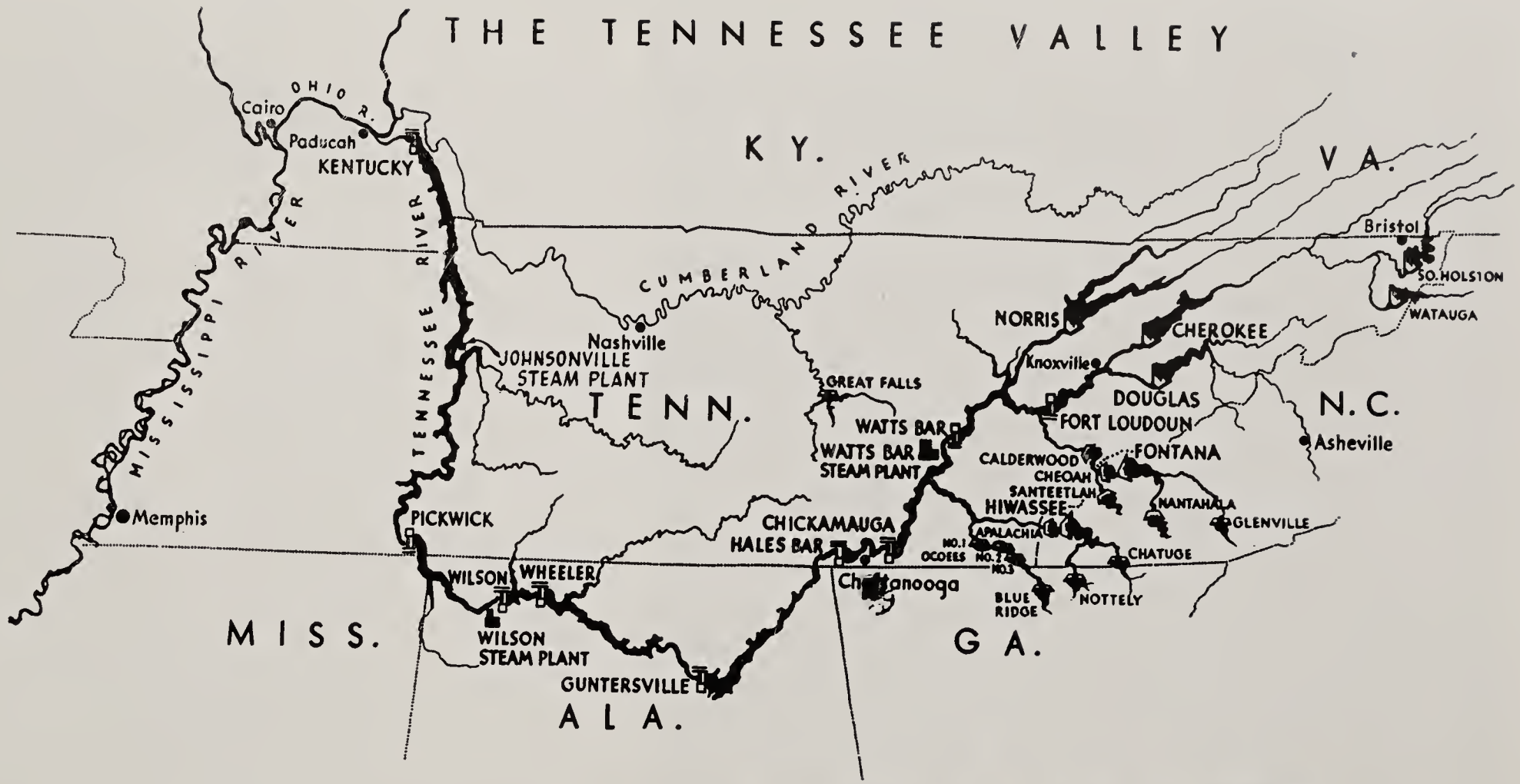
Hundreds of American and foreign technicians, administrators, and professional personnel come annually to study TVA. Representation from other countries includes distinguished statesmen. Among recent visitors were (1) Prime Minister Nehru of India; (2) Hector McNeil, British Minister of State; (3) President Dutra of Brazil; (4) Norwegian labor leaders; (5) members of the Constitution Assembly of Burma; (6) Trygve Lie, Secretary-General, UN Assembly; and (7) delegates to the UN Scientific Conference visit Chickamauga Dam.

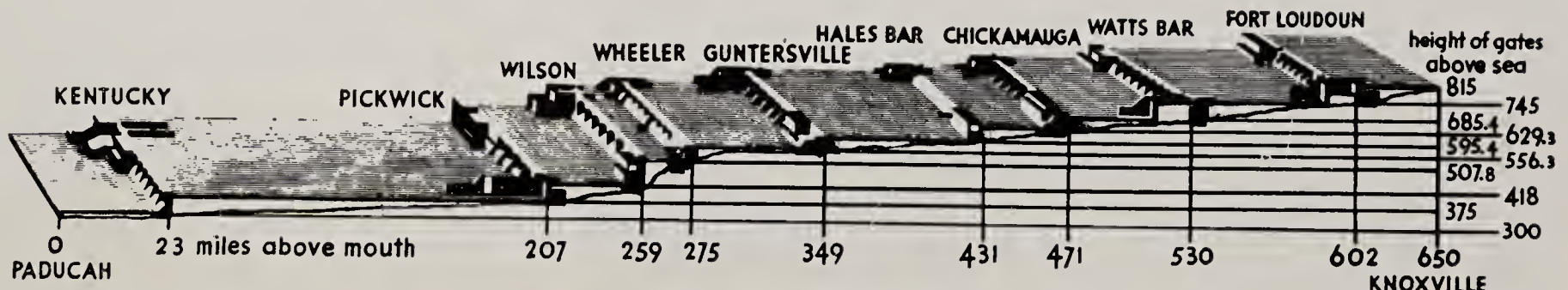


These photos illustrate two uses to which the chain of lakes in the Tennessee Valley are being put. Steel in quantity is moving by barge; one is shown being unloaded at Chattanooga. Traffic on the river in calendar year 1948 totaled 427,850,000 ton-miles, including grain, automobiles, forest products, coal and many other items. The lakes, also, are affording recreation for thousands of citizens. Nearly $16,000,000 has been invested by States, cities, counties, and private individuals in recreation facilities. Pictured is a boat dock on Pickwick Lake.



Today the scene at the top is typical within the Tennessee Valley; one sees good pasture, green winter cover crops and cattle. Electric power is always in evidence. In forestry, too, progress is being made. Many timber owners have adopted sustained yield cutting practices, millions more acres are under fire protection, and hundreds of millions of trees have been planted. Dale Campbell, Calloway County, Ky. (below), "sick and tired of gullies," made planting loblolly pines on worn-out land his 4–H project. Now he has a growing cash crop.





PROFILE OF THE TENNESSEE RIVER

A "newcomer" to the Valley map this year is the location of the Johnsonville Steam Plant in west Tennessee. It will provide 375,000 kilowatts of generating capacity.

I. The Widening of Economic Choice

The welfare of people depends not only upon the natural resources they have at their disposal, but also upon the means they have to conserve, develop, and use them. The task of TVA over the past 16 years has been to help the people of the Tennessee Valley expand their control over their natural assets of waters, soils, forests, and minerals. TVA has thus helped give them greater scope for their initiative, talents, and intelligence and has brought to them, individually and collectively, wider ranges of economic choice. The end-results of better, more profitable use of resources spring ultimately from the activities of the citizens of the region, working with the greater economic elbow room made possible by TVA.

The ways in which TVA contributes to the regional growth are varied. Among them is the construction and operation of a multiple-purpose system of dams of a size and purpose beyond the scope of private enterprise. TVA also operates large chemical facilities at Muscle Shoals for the experimental production of improved soil minerals and other fertilizers; the same plants are available in case of need for national defense purposes. One of the most important aids to development in the region is making available to farm and forest owners the materials, techniques, and knowledge they need to develop and use more effectively their lands and timber. Study and solution of problems which are bottlenecks to full development of resources constitute an important phase of TVA's work.

In most of the fields of resource development, TVA does not have sole or even major responsibility. It does, however, have the broad responsibility under the TVA Act of viewing all the resources of the region in their relationship to one another and of seeking to coordinate all forces affecting them so that maximum results will be obtained. TVA has the power to prevent the erection of obstruction in the Tennessee River and its tributaries, a type of power traditionally exercised by the Federal Government, but away from the river the conservation and efficient use of resources is the responsibility of the private owners of the agricultural, forests, and mineral lands. Moreover, in these fields many other agencies—Federal, State, and local—have responsibilities and carry on activities.

The role of TVA, therefore, is that of promoting and assisting in coordination of effort, of technical advice and assistance, of coopera-

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tion in research and development, and of education and demonstration. Progress depends primarily upon the persuasive power of facts, carefully gathered through surveys and research, marshalled into orderly and usable form, and brought to the attention of the owners of natural resources in ways which promote their use. The facts must carry the conviction that new facilities, new methods, new processes, and new materials will open profitable opportunities in connection with the conservation and use of resources. This attitude and procedure has been bringing results. In many ways, the indices show, the people of the Valley region have forged ahead faster than the Nation as a whole and faster than adjoining areas of the Southeast.

Region Rich But Exploited

The Tennessee Valley is a naturally rich region although, having been settled relatively early in the history of the country, its resources have suffered from poor management, exploitation, and neglect. It is an area of practically 41,000 square miles in 7 States that is threaded by one of the great rivers of the country in point of stream flow. The river's sources lie among the 6,500-foot peaks of the Great Smoky and Blue Ridge Mountains, where rainfall in some places averages 70 inches a year, and it drops to 300 feet above sea level at its mouth. The river and its fan of tributaries thread a region with a natural wealth of soils, forests, and minerals; it has a favorable climate, with ample rainfall generally well distributed, and long, frost-free growing seasons. A little over half the area is forested.

The agricultural soils are favorable to such crops as small grains, a wide variety of legumes and grasses, many truck crops, corn and tobacco, and, in some areas, cotton. The soils have their drawbacks, including much steep and rolling land, the long periods in which leaching and decomposition proceed with resultant low content of lime and other soil minerals and of organic matter, and tendencies toward easy erosion. On the other hand, the soils are capable of responding greatly to good management, including the addition of soil minerals and the growing of vegetative cover which stems erosion.

Forests and woodlands, covering 14,000,000 acres, grow quickly and provide a variety of timber and forest products. Most of the virgin timber has disappeared, but the second and third growth provide an annual income of $200,000,000. With the climate, the variety of forest soils, and the range of elevation favoring the development of many species of hardwoods and pines from which a diversity of products can be made, this annual income could be increased several times.

Mineral resources of the region are likewise varied, although deposits, except for bituminous coal, are generally small. Phosphate rock reserves, although substantial, are small and limited in compari-

son to those of the far West and Florida. The region has sometimes been referred to as a "minerals sample case." Some of its deposits are important strategically and many of them are promising for small business development.

Expanding Control Over Resources

The past 16 years have seen these regional resources of water, soil, forests, and minerals, brought more fully under control and put to work. TVA has constructed 17 dams, and today an integrated system of 27 major dams and reservoirs controls the river system. The danger of floods, both in the Tennessee Valley and in the lower Ohio and Mississippi Basins, has been reduced, with benefits estimated at more than $11,000,000 annually. A navigation channel of 630 miles, connecting with the inland waterway system of the United States, has been put increasingly into use, carrying in the 1949 fiscal year more than 431,000,000 ton-miles of traffic in automobiles, wheat and corn, iron and steel products, coal, petroleum, and other higher value products, where once its usefulness was limited to the transport of sand and gravel, railroad ties, and similar products over short distances.

Power available in the region has been multiplied 10 times, from 1,500,000,000 kilowatt-hours in 1933 to nearly 16,000,000,000 kilowatt-hours, with great impact upon the economic life of the region. An increasingly large proportion of this power has been distributed and put to work by the people of the region through 144 municipal and cooperative systems, locally owned and managed, and now serving more than a million consumers. The availability of this supply of energy has helped greatly in enabling the people of the region to make better use of their other resources. It has helped promote the growth of industry and employment based on the regional resources and has led to greater processing of regional products. TVA also uses power in its own operations, delivers large amounts to the atomic energy plant at Oak Ridge, and sells energy to a few large industries.

Aggressive rural electrification activities of the distributors, aided by REA and TVA, have expanded the number of farms served in the TVA power area from about 3 percent in 1933 to 66 percent at the close of the last fiscal year. This expansion, plus much greater use per farm, has multiplied farm use of electricity by some 50 times in the past 16 years. It is helping open the way to better use of the agricultural resources of the region by enabling farmers to engage in more diversified farm operations, to turn more easily to dairying and livestock growing, to produce more with less labor, and to achieve better prices for more varieties of farm produce through local preservation and processing industries.

One of the measures of the value of power in the region is the fact that despite the multiplication of power available, the demand is still rising rapidly and steadily. Additional supplies of power, which TVA is taking steps to provide through both steam and hydro extensions of its generating capacity, are urgently needed both to meet the normal load growth and to assure the industrial and agricultural development justified by the area's basic resources.

In addition to flood control, navigation, and power, harnessing of the river has provided substantial subsidiary benefits. Malaria has been reduced to the point of practical disappearance in problem areas along the river. The reservoirs have provided a recreation asset which is coming into constantly greater use for boating, swimming, hunting, and fishing. Favorable habitats for fish and wildfowl have been vastly expanded. Besides the sport and relaxation which they provide, the reservoirs are attracting increasing investments of recreation industry, both public and private—$3,000,000 in a single year.

Moving to the land, the TVA, in accordance with its responsibilities under the TVA Act, has used the chemical plants at Muscle Shoals for the development of improved soil mineral fertilizers, and particularly of phosphate, and at the same time maintained them for munitions production in case of need. Lack of phosphate in many of the soils of the region has been a limiting factor; its use is essential to soil-and-water conserving agriculture. Soil mineral fertilizers channeled into expanding use through practical farm test-demonstrations under the supervision of the State agricultural extension services and their county agents, are helping to transform the agriculture of the region in the direction of diversity and stability. These fertilizers enable the region's farmers to grow more cover crops protecting the soils from erosion and capturing rainfall for the use of plants. Used to produce small grains, legume, and forage crops, the soil minerals help make it desirable and profitable to shift farming operations in the direction of dairying and livestock production, replacing reliance upon cash row crops which all too often have proved soil-depleting in the past. Continuing investigation and promotion of improved fertilization practices have led also to the use of nitrate fertilizers, hitherto used principally to stimulate the growth of cash crops, in furthering the early growth of winter cover crops that protect the soil.

As the result of research undertaken by TVA and agricultural and engineering experiment stations in the Valley has come improved machinery equipment to meet the problems arising from basic shift in agricultural practices. Among recent projects, for example, are studies and demonstrations of pasture irrigation as a profitable aid to milk production, and investigations on mulch tillage for the seed-

ing of small grains, grasses, and legumes. Such activities, and many more, are assisting the farmers of the region in more effectively using their soil resources and widening the range of choice they have in the kind of farm operations in which they engage. Research in food processing and preservation, carried on in cooperation with State agencies, has helped provide better, more stable markets for farm produce, a further stimulus to better farming operations.

Progress has been made in providing better protection and more efficient management of the forests and woodlands of the region, 83 percent of which are in private ownership. The extension of organized protection against fire to some 7,500,000 acres since 1933, making a total of 10,000,000 acres now protected, has helped to make modern forest management a more attractive enterprise. This has been accomplished through cooperation with State and local agencies of government and with private landowners, in which the role of TVA has been largely that of education and stimulation of interest, plus technical assistance and advice and moderate financial assistance in the early stages.

Both large and small forest management demonstrations have been set up, in cooperation with forest and farm woodland owners and with State and county forestry agencies, to demonstrate the profitableness of selective cutting and other practices which preserve the forests as a continuing asset. Through such demonstrations, modern forestry practices spread to adjoining forest-land owners. Research in connection with forests includes investigations to improve or introduce new tree species, to find new ways of preserving nondurable woods, and to perfect a process for converting wood wastes and low quality hardwoods into molasses and thence into other usable products.

TVA forest nurseries have provided about 200,000,000 tree seedlings for the reforestation of eroded and abandoned lands, mostly privately owned, thus returning them to productiveness.

Research on minerals of the region, through field studies for the location of usable deposits and exploration of methods of processing, have helped people take advantage of another class of resources. For example, sillimanite deposits have been located and mapped in North and South Carolina and in Georgia, through cooperation with State natural resource agencies, and development of processes by which the mineral can be used as a substitute for Indian kyanite is being initiated. In such investigations, the facilities of the TVA chemical plants at Wilson Dam, the United States Bureau of Mines Laboratory at Norris, Tenn., the Asheville, N. C., State minerals laboratory which TVA helped establish, and facilities of Clemson College are used. Such activities have resulted in expanding use by private industry of mica, native kaolins, and halloysite.

Evidences of Progress

Private enterprise has prospered and advanced in the region. This is the ultimate justification for the activities of the Government as represented by TVA. The objective of TVA, as expressed in the TVA Act, is not to restrict but to foster increasing control of the people of the region over their resources. This objective is apparent in the methods employed in furthering development of the Valley.

The increasing control of the people over their resources and the more numerous economic choices they enjoy are reflected in a number of ways. The agricultural resources are being placed on a sounder plane, and at the same time production is increasing. In the Valley region, soil and water conserving practices are expanding more rapidly than in adjoining areas. This is evidenced by the proportionately more intensive use of soil minerals such as phosphate and lime per acre of open land, in the relative reduction in acreage of row crops which leave the soils open to winter rains and erosion, in the relative increase of acreages of hay and small grains and soil-conserving legumes, in the decrease in the proportion of idle or fallow land, and in the increases in number of cattle and in milk production.

The marked expansion of farm electric service, plus farm mechanization, fertilization, and improved farm practices have enabled the farmers of the region to increase production, and with 93,000 fewer farm workers in 1947 than in 1933. At the same time, industrial expansion and increasing urbanization have opened up new job opportunities. In 1947, manufacturing plants in the Valley employed 158,000 more workers than they did in 1933. This was an increase of 147 percent, as compared with a 119 percent increase in the country as a whole. Income of proprietors and employees of manufacturing plants increased from $83,200,000 in 1933 to $623,200,000 in 1947. Where the income from manufacturing was 19 percent of total income in 1933, it was 23 percent in 1947. The number of employees in trades and service enterprises increased by 145,000 between 1933 and 1947, while the income of proprietors and employees grew from $145,700,000 to $910,000,000. This increase of 525 percent compares with 307 percent for the Nation. Incomes of proprietors and employees of mining enterprises increased 663 percent, from $11,600,000 to $88,500,000, as compared with a national gain of 348 percent. The employment increase from 20,000 to 29,000 was 45 percent, as compared with the national gain of 24 percent.

Average income per capita in the Tennessee Valley proper increased from $148 in 1933 to $797 in 1947, while that in the United States went up from $368 to $1,323. While per capita income in the region is still 40 percent below the national average, there has been a great improvement in its relative position.

The stimulus provided by the TVA activities and the opportunities it has created for expansion has helped bring about an increased interest in the States in natural resource development and has helped strengthen and broaden their programs. One of the criteria is the fact that the total expenditures of the Valley States (Tennessee, Alabama, Mississippi, Georgia, North Carolina, Virginia, and Kentucky) for resource programs have increased from $13,000,000 in the fiscal year 1939 to $28,000,000 in 1948. Such activities have been encouraged by the TVA in the conviction that the most effective development of resources will come about through the initiative and active concern of the people of the region and their agencies. Fish and game conservation work and park developments have expanded in the States to take advantage of the opportunities afforded by the TVA development.

State and local planning have become accepted activities, where State and local planning agencies were nonexistent or nearly dormant. As an example, the TVA contracted with the State of Tennessee to carry out some planning studies required in connection with some of its earlier projects. In order to carry out the contract, the State created a planning commission with an initial appropriation of $10,000. In subsequent years, the planning commission has been continually expanded and the last annual appropriation was $125,000. TVA financial support was long ago withdrawn, although it still gains from the services of the commission. Over the same period, local planning bodies, assisted by the State commission and TVA, came into existence and 117 of them are now active. The same pattern of development has occurred in other States.

Benefits Extend Beyond Region

While the people of the Tennessee Valley have benefited through the more efficient and profitable use of their resources, the benefits of the TVA development are not confined to the region. The betterment of economic conditions in the Valley is reflected in advantages spreading far outside. The combination of greater income plus availability of low-cost power has made the region one of the better markets in the country for domestic electric appliances. Residential users of TVA power purchased an estimated $100,000,000 worth of electric ranges, refrigerators, water heaters, washing machines, and other appliances during 1948, most of them coming from other regions. During the fiscal year 1949, the municipalities and cooperatives invested $56,000,000 in expansion and improvement of their systems, with much of the money going for purchase of electrical equipment manufactured elsewhere. TVA's own purchases of materials (generating equipment for its dams, for example) outside the Tennessee Valley States have amounted to $325,000,000 out of a total invested in materials of

$579,000,000 since 1933. TVA's power revenues of $58,000,000 in the fiscal year yielded a net operating revenue of $21,500,000, or 5 percent return on the Government's power investment.

Expansion of river traffic has called for increasing services of towboats and barges. While there can be no clear measure of the stimulus to boat building, it is estimated that the cost of a fleet capable of carrying the 1948 traffic on the Tennessee River under practically ideal operating conditions would amount to some $7,000,000 at postwar prices. The nearly 1,400 inboard pleasure boats (cruisers, speedboats, runabouts) on the lakes in 1948 are estimated to represent an investment of some $4,600,000, with smaller boats, numbering nearly 10,000, worth another $1,000,000. It is clear that better management of resources and resultant higher incomes have made the Tennessee Valley region a better market for automobiles, clothing, farm machinery, sporting goods, and a host of other products.

TVA's chemical research at Muscle Shoals, ranging from laboratory through plant-scale operations, has been drawn upon increasingly by private enterprise. At least three plants in the West have been built on the basis of TVA research, while many others, both in the Valley and outside, have used TVA findings in making improvements. One of the objectives of TVA research on concentrated phosphates has been the encouragement of use of the great reserves of the far West upon which the middle West "bread basket" ultimately must depend for this essential soil mineral.

The Valley is becoming more and more productive both agriculturally and industrially. Its resources, brought more intensively under control and being more efficiently conserved and used, have strengthened both the region and the country as a whole. In the following sections of this report, the work of TVA in contributing to this progress is covered in greater detail.

II. The River in Use

Closure of Watauga Dam during the 1949 fiscal year brought to 27 the number of major dams in the multiple-purpose system controlling the Tennessee River and its tributaries. The increasing usefulness of the developed streams in the economic life of the region was apparent in growing commerce on the navigation channel, in aversion of damages due to floods and in greater power production. In addition, other substantial regional benefits were apparent in the expansion of recreation facilities and in fish and wildlife conservation.

The navigation channel, extending 630 miles from Knoxville to the Ohio River at Paducah, Ky., carried 427,850,000 ton-miles of traffic in the calendar year 1948, an increase of 21 percent over the previous year. Volume continued to increase during the first 6 months of 1949. Savings in freight charges were estimated at more than $4,000,000, exceeding all the current costs of operation of the waterway.

No major floods occurred during the year, but regulation of two moderate floods averted more than a million dollars in damage in the Tennessee and lower Ohio and Mississippi basins.

The power system, augmented by 190,000 kilowatts of additional installed capacity, produced more than 15,000,000,000 kilowatt-hours of electricity for which consumers paid $100,000,000.

Increased use of TVA lakes for recreation by citizens not only of the Valley but from other sections of the country was reported from all developed areas. Facilities to provide for this growing use were being added rapidly. Recreation investments by State and local governments, quasipublic organizations, and individuals along TVA lake shores increased by $3,000,000 during the year bringing the total so invested to nearly $16,000,000. Wildfowl were finding the lakes a favorable habitat and were increasing in numbers.

All this was in sharp contrast to the situation in 1933, when the river was navigable only in relatively short, unconnected stretches, floods were an annual threat, and power production of the TVA region was only a tenth of what it is today. In brief, the river has been transformed from a liability to a great asset, both for the people of the immediate region and for the Nation.

FPC Reviews Multiple-Purpose Allocation

The TVA pioneered in the full development of all the values which could be achieved by river control by the construction and operation of a multiple-purpose system of dams. While single dams had sometimes been built previously for more than one purpose, such as reclamation and power production, or navigation and power, the TVA system was the first to be authorized and constructed to control an entire river system in order to realize the full potential benefits. This posed a number of problems in planning, design, construction, and operation. Operating techniques, for example, had to be worked out as the system expanded in order to preserve the priorities of flood control and navigation, as provided in the TVA Act, and obtain maximum production of electric power consistent with these primary purposes.

Another problem was that of allocation of the investment among the major purposes of the system. Section 14 of the TVA Act directed that such an allocation be made by the TVA and provided that the allocation, "when approved by the President of the United States, shall be final." The first allocation report, made in 1938, was the result of several years of intensive study by TVA staff and a distinguished group of consultants. The group examined in detail all the possible theories of allocation. The allocation finally made, although it involved an exercise of judgment, followed closely the principle of "alternative justifiable expenditure."

In brief, this method of allocation involves distributing the common costs of the TVA projects (reservoir lands, spillway, and nonoverflow sections of dams, etc., as compared with navigation locks, powerhouses, and generators, etc., which are charged directly to the purposes they serve) in proportion to the costs of achieving flood control, navigation, and power production by means of single-purpose systems. This system has been followed in subsequent allocations as additional projects were completed and brought into the system.

At June 30, 1949, the total investment of $816,000,000 in the multiple-purpose water-control system was distributed as follows: $151,500,000, or about 19 percent to navigation; $154,000,000, or about 19 percent to flood control; and $510,500,000, or about 62 percent to power.

Despite the intensive study which went into the determination of allocation, it has been suggested from time to time and from various sources, including the Corporations Audits Division of the General Accounting Office which annually audits TVA's accounts, that the principles and the validity of the allocation should be reviewed by some other agency, preferably the Federal Power Commission, which had made allocations for other Federal projects.

The opportunity for such a review was provided in 1948 through the request of the chairman of a subcommittee of the Senate Committee on Public Works. He asked the Federal Power Commission, with the assistance of the Corps of Engineers, United States Army, and the General Accounting Office, to make "an impartial and independent review of the principles and methods followed by TVA in making the allocations." It was suggested that the allocated investments in flood control and navigation might not be justified on the basis of the benefits to be derived and that, in consequence, an insufficient proportion of the investment was being charged against power operations.

The Federal Power Commission completed its investigation of the TVA allocations on March 23, 1949, and its report made public several months thereafter. Its conclusions were as follows:

A. The alternative single-purpose projects are justifiable on a cost-benefit ratio basis, and the use of the estimated costs of such projects in arriving at the percentages for allocating joint costs * * * is reasonable;

B. The principles and method employed by TVA in allocating the joint costs of its multiple-purpose projects are reasonably adapted for the purpose;

C. The allocation of the actual joint costs of the mutliple-purpose projects to navigation, flood control, and power made by TVA in its report dated November 13, 1945, is reasonable and should be accepted for the purposes of the Tennessee Valley Authority Act.

The report of the FPC came shortly after Haskins & Sells, certified public accountants of New York, with long experience in the utility field, in a task-force report to the Hoover Commission said: "the Authority [TVA] is presently earning more than sufficient revenues from power operations to repay the investment in power facilities with interest." This statement, together with the confirmation of TVA's allocation by the Federal Power Commission, makes a complete and responsible answer to those who may have been led to believe that TVA's power operations are subsidized.

Lowest Benefits Outweigh Highest Costs

The conclusions of the Federal Power Commission were based upon estimates of the annual benefits of navigation and flood control as compared with annual costs. From these conclusions it is apparent that under TVA's allocation the Nation is receiving flood control and navigation benefits at bargain prices. In brief the FPC reported:

That the lowest estimate of annual navigation benefits was $9,104,000, while the highest estimate of annual costs on an alternative single-purpose system, including depreciation and interest, was $8,228,000. The cost of the alternative system used in determining the annual costs was $217,532,000. In comparison, the actual TVA investment at June 30, 1949, was $151,500,000, or $66,000,000 less.

That the lowest estimate of annual flood-control benefits was $8,963,000, whereas the estimated annual costs, including interest and depreciation, for the alternative flood-control system were $7,295,000. The estimated cost of the alternative system used in making the calculations as to annual cost was $227,704,000, as compared with TVA's actual investment at June 30, 1949, of $154,169,000, or $73,500,000 less.

The FPC reported that it had made a "cursory review" of TVA's estimates of the costs of an alternative single-purpose power system as compared with the benefits. "Our cursory review confirms the TVA finding, indicating power benefits would exceed power costs," the Commission said. "Inasmuch, however, as no one apparently has claimed that the costs allocated to power by TVA should be reduced, it would appear to be unnecessary to make a more detailed study of the cost benefit ratio of an alternative single-purpose power system."

The considerably lower investments in navigation and flood control in the multiple-purpose system as compared with the alternative justifiable single-purpose systems would be reflected in considerably lower annual costs. The major reduction would be in interest costs, while the reduction in depreciation costs would be substantial.

The estimated annual costs of both flood control and navigation as found by the Commission would be reduced about $2,000,000 for each of the purposes due to the reduction of interest and depreciation because of the lower capital investment for these purposes in the multiple-purpose system.

As noted above, the lowest estimates of benefits were used by the Commission in making its determinations, and these estimates are confined to direct benefits only, such as savings in freight charges on the navigation channel and aversion of damages or increases in property values due to flood control. In both cases, there are less tangible benefits upon which a money value could hardly be placed with any precision.

TVA has estimated, for example, that the savings in freight charges on the navigation channel will approximate $9,000,000 on the basis of "matured" traffic of 7,000,000 tons annually. This sum will be sufficient to cover all the annual costs of the navigation channel. These include not only those of TVA but the costs of the United States Army Engineers in maintaining the channel (a small amount of dredging may occasionally be necessary) and operating the locks and of the Coast Guard, which on the Tennessee, as on other navigable waters, maintains navigation aids and enforces navigation regulations. In addition, it would leave a sum equaling a rate of return on the navigation investment substantially exceeding the cost of money to the Government.

In addition to these direct benefits, however, there are others: New

business opportunities for barge lines and builders of towboats and barges; development of river cities as distribution centers for grain, petroleum, automobiles, steel, etc.; the expansion of economically accessible markets for coal; the value to the Valley of availability of cheaper midwestern grains; expansion of markets and more economical sources of supply for established businesses and opportunities for development of new business; widespread use of the river by citizens generally for recreation; and more advantageous railroad-freight rates through the existence of a competitive form of transportation. Such benefits, in the aggregate, probably exceed the direct savings in transportation charges.

The same is true of flood control. The benefits of present TVA flood-control system have been estimated at $11,000,000 annually, more than half of it attributable to the lower Ohio and Mississippi basins. In addition to these direct benefits, there are the additional intangible benefits such as avoidance of possible loss of life, disruption of economic activities through damage to communication and transportation facilities, and of hazards to health from damage to water supplies and sanitary facilities.

Waterway Traffic Trends Upward

A greater volume of higher-value freight moved longer distances on the Tennessee waterway than ever before. The 427,850,000 ton-miles of traffic carried in the calendar year 1948 was 13 times as great as in 1933, when traffic was limited chiefly to short hauls of low-value sand and gravel and forest products. It was 21-percent greater than the 350,000,000 ton-miles carried in 1947, which in turn was nearly 37 percent higher than in 1945, which had the greatest ton-mileage up to that time. (In 1946, after the war, ton-mileage dropped to less than 200,000,000.) The upward trend was continuing, with estimated traffic in the first half of 1949 being about 18 percent higher than the same period the year before.

Transportation savings on 1948 traffic were estimated at $4,000,000, one-third more than in the previous year, and more than equal to the current costs of operation, including depreciation, plus the expenses of the United States Army Engineers and the United States Coast Guard in carrying out their navigation responsibilities on the Tennessee.

Most of the traffic in higher value commodities originated or terminated at points outside the Valley. It consisted, for example, of petroleum products from the Southwest and the Midwest; of grains from the Midwest; of automobiles from the North Central States; of coal and coke from Ohio River ports; of iron and steel from the Upper Ohio River; of phosphate fertilizer moving to Midwest distributors;

of forest products moving to Ohio and Mississippi River processing plants.

In 1948 about 48 different towboats operated by 18 barge lines worked on the Tennessee River hauling the 1,170,000 tons of higher value commodities (excluding nearly 2,000,000 tons of short-haul traffic in sand and gravel), most of which moved long distances on both the Tennessee and connecting waterways. Nine times as much of this sort of traffic was hauled in 1948 as in 1933, and the average length of haul on the Tennessee was over twice as great. Admittedly business conditions in the 2 years were sharply different, but the fact remains that it would have been physically impossible to move most of the 1948 traffic on the river as it existed in 1933. The barge line revenues from the 1948 traffic are estimated at $3,500,000.

The postwar period has been one of tremendous activity among builders of inland-waterway vessels. A factor in this activity has been the traffic demand of the Tennessee River which it is estimated would require a fleet costing $7,000,000 at present-day prices.

Distribution Patterns Changed

The growth of traffic on the river has been accompanied by changes in the pattern of business and agriculture in the Valley. In some instances the apparent changes are largely confined to the individual concerns which have turned to river transportation. In other cases the changes apply to a whole industry or to the whole Valley.

For example, the petroleum industry has completely changed its distribution methods and organization in the Valley region in the past 10 years. Distribution of finished products is no longer from the refineries but from bulk storage facilities established in the Valley. Some companies have turned to pipe-line transportation; others are using the Tennessee River. Two pipe-line terminals have been established at Chattanooga and one at Knoxville. Eleven river terminals have been established at six ports on the Tennessee River, serving at least seven different companies. Knoxville, at the head of navigation, is now receiving about 40 percent of its total gasoline supplies by water, whereas prior to 1946 no river shipments were handled. It is now a major distribution point for petroleum products; approximately three-fourths of the 265,000 tons of refined products handled at Knoxville's three river terminals in 1948 was shipped by rail or truck to inland points.

Guntersville, Ala., has become a distribution point for automobiles since a transportation company which specializes in handling automobiles started using the Tennessee River. In 1948 about 19,000 automobiles arrived there by barge and were shipped out by truck carrier to 175 destinations in 6 States.

Both Decatur and Guntersville, Ala., have become important receiving and distribution points for river-shipped midwestern grains—the two together handled 97 percent of the total 1948 river traffic in that commodity. Four grain terminals and storage elevators have been built, two at each port—in each case to take advantage of cheaper river transportation in reaching the southeastern market. The elevators located in North Alabama have also provided a new market for locally-grown grains, with the result that one of the concerns at Decatur alone paid local farmers over $1,400,000 for their grains in 1948.

Late in the fiscal year shipments of steel from Pennsylvania ports on the Ohio River began arriving in quantity for use of fabricators in the Chattanooga area.

Water-Control Operations

TVA operates the 27 major reservoirs in the water-control system, as directed by the TVA Act, for the primary purposes of flood control, navigation, and production of electric power. Storage and release of waters for all purposes is directed from a central water control planning office in Knoxville.

In operating the system, requirements call for the reservoirs to be at low levels to provide more than 11,000,000 acre-feet (an acre-foot is the amount of water required to cover 1 acre to a depth of 1 foot) of storage at the beginning of the major-flood season January 1. During the flood season, filling takes place only temporarily as required to control floods and the water is released immediately after the flood danger has passed. As the flood season advances and the possibilities of floods recede, the storage reservoirs on the tributaries are gradually filled. During this period, the main power load is carried by the mainstream hydro plants of the system.

With the onset of the dry season in late summer and fall, the process is reversed and water is released from storage, generating power not only at the projects where it is released but at all downstream generating stations. Water released through the turbines at Fontana Dam, for example, is used through 10 additional power plants downstream.

The withdrawal of water from the reservoirs for power production automatically provides storage capacity for use during the next flood season.

Flood Damage Averted

Although there were no major floods during the fiscal year 1949 comparable to those of the three preceding years, the crests of two lesser floods in the Valley were reduced with resultant savings in flood damage estimated at more than $860,000 at Chattanooga.

The first of these floods occurred in November 1948, when rainfall of 9.7 inches, 196 percent above normal for the month, fell in the basin above Chattanooga. The greater part of the rain fell in the last of four storm periods during the month and, without the control of TVA reservoirs, would have caused a flood crest of 35.7 feet at Chattanooga. The actual controlled crest was 29 feet, a reduction of 6.7 feet which averted about $360,000 in damage.

In January 1949, a second flood was reduced by 6.8 feet, from a natural stage of 36.3 feet to a controlled crest of 29.5 feet, averting about $500,000 in damage. Estimates of damage averted are based upon careful surveys of the property which would be affected at different flood levels. The most recent survey, conducted last year, showed that a recurrence of the largest flood ever recorded, if uncontrolled, would cause damage of about $100,000,000 at Chattanooga, the most vulnerable point in the Tennessee Valley. However, complete protection for the city against a possible flood more than 50 percent greater than that of record requires a levee system at Chattanooga to supplement the control by reservoirs. Construction of such a levee system by the Army engineers has been authorized, but the city has not yet agreed to meet the requirement of local participation, including the acquisition of the necessary land.

Damage averted at Chattanooga since Norris Dam, the first project constructed by TVA, went into operation totaled an estimated $41,536,000 at the end of the fiscal year.

No serious floods occurred on the Ohio River at Cairo, Ill., during the year, but two lesser flood crests were reduced by 0.7 foot and 1.2 feet respectively, and estimated damage averted amounted to $200,000. In accordance with procedures worked out over the years for cooperation in control of floods, TVA and the United States Army Engineers exchanged stream flow reports and predictions during the periods January 6 to March 14 and March 28 to April 8, when the Ohio River stage at Cairo was 35 feet or higher. The highest stage on the Cairo gage during the year was 50.5 feet, reduced 0.7 foot from the natural crest by TVA reservoir control.

Watauga Dam Completed

Excellent progress was made during the year on construction projects in the river-control program. Watauga Dam, the seventeenth to be constructed by TVA, was closed as scheduled on December 1, 1948, and filling of the reservoir proceeded at a satisfactory rate. This project adds 260,000 acre-feet of flood-storage capacity in the Valley water-control system besides providing local-flood protection. The first of two 25,000-kilowatt generating units was placed in operation shortly after the close of the fiscal year.

Construction of the dam was started in February 1942, but later was stopped by order of the War Production Board. It was resumed after the war. The dam is an earth- and rock-fill structure 318 feet high and 900 feet long. It creates a reservoir with a total volume of 678,800 acre-feet and useful storage of 627,000 acre-feet. The lake is 17 miles long and has 106 miles of shoreline. The project is located on the Watauga River, a tributary of the South Fork Holston, in east Tennessee.

Construction of South Holston Dam, also started in 1942 and later stopped by WPB, progressed rapidly during fiscal 1949. Work was confined chiefly to placing of earth- and rock-fill, and at the close of the fiscal year 3,300,000 cubic yards had been placed, out of a total of 5,900,000 required. This project, in east Tennessee on the South Fork of the Holston River, is scheduled for initial operation in November 1950. It will be an earth- and rock-fill dam 285 feet high and 1,600 feet long. The reservoir, with a total volume of 873,000 acre-feet and useful storage of 660,000 acre-feet, will be 25 miles long, with 168 miles of shoreline.

It will provide local flood protection and add 300,000 acre-feet of flood-control storage to the TVA system. The planned power installation is a single 35,000-kilowatt generating unit.

Hales Bar Pool Level Raised

Completion of construction for improvement of the Hales Bar Dam permitted the reservoir to be raised to its normal operating level 634 feet above sea level. This is nearly 5 feet above the level of the reservoir as it existed at the time TVA acquired the project from a private power company.

Raising the level of the reservoir, plus a small amount of dredging in the upper reaches, assured full project depth of 11 feet for navigation to the foot of Chickamauga Dam, 7 miles above Chattanooga, Tenn.

The work involved cutting down the spillway and installing 17 radial gates 19 feet high by 40 feet long. Besides the benefit to navigation depths, the installation of the gates makes for more flexible operation of the project in flood control and other water-control operations. Other improvements at the project included extension of the lower lock guard wall and installation of new operating machinery for lock valves and gates.

Alterations at the dam were completed early in the fiscal year, but filling of the reservoir to the new operating level was delayed pending agreement with the city of Chattanooga as to readjustments of the sewer system there. The new level was reached on May 25, 1949.

Steam Plant Construction Started

Congressional approval of the New Johnsonville steam plant, on the shore of Kentucky reservoir in west Tennessee, which will add 337,500 kilowatts of rated capacity to the system, was given May 12. By the end of June, the construction of access roads and railroads was well along, 140,000 cubic yards of site grading had been finished. Foundations for most of the camp buildings were completed and work started on the structures. Three barge loads of buildings used in the construction of Kentucky Dam were shipped to New Johnsonville for use there. The first of three units at this plant is expected to be placed in operation late in 1951. New hydro-generating capacity totaling 154,800 kilowatts was completed by TVA and placed in operation during the year, out of more than 400,000 kilowatts under construction. Installation was progressing on the remaining 257,600 kilowatts, and plans were being advanced for 171,900 kilowatts additional at existing plants.

At Douglas Dam, installation of the third unit, with a capacity of 26,000 kilowatts, was virtually completed. At Fort Loudoun, two units were placed in operation, making four in all and completing the 128,000-kilowatt installation at that dam. At Wheeler Dam, two 32,400-kilowatt units were placed in operation, bringing the installation to a total of 194,400 kilowatts. Installation of the two remaining units was well underway. At Wilson Dam, installation of the last four of 18 units was started in October 1948; with the completion of these units, Wilson Dam will have an installed capacity of 436,000 kilowatts, the largest hydro-installation on the system.

At Wilbur Dam, a relatively small dam acquired from a private power company, work was going forward on the extension of the powerhouse and the substructure for a new 7,000-kilowatt unit. During the year, the crest of the old spillway of this dam was cut off and replaced with a new overflow spillway with 15 x 40-foot radial gates. The generating capacity is being increased from 3,700 to 10,700 kilowatts to take advantage of regulation of water by Watauga Dam, immediately upstream.

At Pickwick Landing Dam, raising the lower lock guard wall by 11 feet, 3 inches was virtually completed during the year. Raising of the wall gives better protection to navigation against waves from the spillway discharge.

Dredging at Wilson Dam to widen and deepen the channel between lock and Dam No. 1 and the Wilson locks was virtually completed during the year. The channel was brought to the full channel requirements of 11-foot depth and 300-foot width. Dredging below Guntersville Dam was about 80 percent complete. Other dredging operations were carried on to establish three safety harbors on Wheeler reservoir.

Management of Reservoir Lands

River development by multipurpose dams requires the acquisition of lands for reservoir purposes. Some land is purchased in fee or, where feasible, flowage easements are obtained. In these purchases TVA has sought to obtain some lands adjacent to the reservoirs to insure that the public will always have access to the lakes. Other land bordering on the lakes has been purchased where the original owner of property to be submerged would be left with an uneconomic unit above the water line. In some other areas land has been purchased where this was less expensive than to provide new roads to reach it or where it was necessary in the control of malaria adjacent to the reservoirs.

Most of the land now in custody of TVA is necessary for operation and protection of the river-control system. However, in addition to this function, much of the land can be, and is, put to other uses without interference with water-control operations. During the fiscal year more than 72,000 acres of the reservoir lands were licensed to farmers for agricultural use. About two-thirds of the licensed acreage was used for soil-conserving hay and pasture crops, encouraged by TVA to reduce soil erosion and bring about an increase in the region's livestock.

Approximately 307,000 acres of the reservoir lands are forested. From this acreage during the fiscal year approximately 6,500,000 board-feet of lumber was harvested by private sawmill owners who paid TVA about $79,000.

TVA has increasingly sought to withdraw from direct operation of its reservoir properties whenever feasible, and encourage private individuals and public agencies to develop and operate them in the interest of maximum beneficial public use. For example, full development of the recreation resources and other values inherent in some of the reservoir lands is highly feasible through the assumption of development and operating responsibilities by State and local agencies and groups. This plan of development is illustrated by activities in the field of recreation.

Recreation Development on Lakes

In the early years, TVA participated with other Federal agencies in building and operating directly several recreation developments for demonstration purposes. At the close of the fiscal year, however, all but one of these demonstration installations had been transferred to private or other public agencies for operation. A lease was being negotiated for private operation of the single exception, and it was signed after the close of the fiscal year. As a result, every recreation operation along the 10,000 miles of shore line now is conducted by a

public agency other than TVA (States, counties, cities) or by private enterprise.

As with other activities, really active development of the recreation resources of the TVA lakes could not take place before the end of the war. Since then, however, the construction and operation of recreation facilities—parks, boat docks, swimming beaches, camps, resorts, and summer cabins—has been rapid. At the end of the calendar year 1948, a detailed survey showed, the investment in recreation on and along the lakes was more than $15,700,000. This was an increase of nearly $3,000,000 in 12 months. At the close of the calendar year, for example, there were nearly 1,400 inboard boats, ranging from cabin cruisers to run-abouts, on the lakes. They were valued at more than $4,600,000. Nearly 10,000 smaller craft were in use, with a value in excess of $1,000,000.

During the year the number of business enterprises operating on lake frontage property grew from 137 to 151, and gross income from $1,855,974 to $2,148,402. The greater portion of expenditures for recreation equipment, supplies, and services is made elsewhere than at operations along the lakes. Boats, motors, fishing rods and reels are usually bought in the towns and cities. From the best estimates available it appears that the Tennessee Valley area now has a tourist and vacation business approximating $175,000,000 per year.

Public agencies—State, counties, and municipalities—to which lands have been leased or transferred for park use are also accelerating development. Kentucky is spending at least $500,000 in development of two State parks, Kentucky Lake and Kentucky Dam State Parks, on Kentucky Lake; the 1949 Legislature of Tennessee appropriated $1,500,000 for park improvements, a part of which is earmarked for improvements in Harrison Bay and Booker T. Washington State Parks on Chickamauga Lake, Paris Landing State Park on Kentucky Lake, and in Cove Lake and Big Ridge State Parks on Norris Lake. (Big Ridge Park is the most recent addition to the Tennessee State Park System.) North Carolina was planning over $100,000 in improvements in Hiwassee Lake State Park at Hiwassee Dam. A number of counties and municipalities have either made, or have completed plans for making, improvements in local parks on TVA lakes.

Fish and Waterfowl Attract Sportsmen

The construction of the reservoirs has created a favorable habitat for fish and wildfowl, and hunting and fishing on the lakes represents a vast increase over that on the natural river. This is a highly encouraging development, considering that in the early days of TVA it was freely predicted that the reservoirs would become "biological deserts."

Creel census records taken during 1949 on a number of reservoirs, and reports from other reservoirs, show that the mainstream waters provided the best fishing in both numbers and pounds of fish caught. Tagging studies were made on two storage and two mainstream reservoirs to determine what proportion of the fish crop was being caught. Low tag returns on mainstream reservoirs indicate that most fish in those waters are not being caught, even with year-round fishing, liberal creel limits, and the increased fishing pressure brought about by growing numbers of out-of-state anglers. Sportsmen are harvesting more of the game-fish crop in storage waters, but there, too, most of the fish crop is not being caught.

The measurable gross income of commercial fishermen this year was $369,520; last year they earned $320,419. These figures do not represent the total value of the commercial catch because many fishermen retail their own fish and no records of their catches are available. The reported commercial catch came close to a million and a half pounds of fish, including over 760,000 pounds of catfish, with lesser quantities of spoonbill, drum, carp, buffalo, and sturgeon.

The southward flight of ducks and geese over the Tennessee Valley reached record proportions during the 1948 fall migration. An incomplete count showed over 140,000 ducks and 4,500 geese on Kentucky, Wheeler, Guntersville, and Chickamauga Reservoirs. The birds are attracted by the 600,000 acres of water in the TVA reservoirs. They stay to enjoy the shelter of the wildlife refuges and to feed from the thousands of acres of land planted to wildfowl food.

Ducks and geese arriving in the Valley last fall found over 5,800 acres of waterfowl food planting, established through the joint efforts of State conservation departments, the United States Fish and Wildlife Service, local farmers, and TVA. Several of the States are going ahead with expansions in waterfowl food acreages for the 1949 season. Tennessee, for example, has recently created the 1,000-acre Paint Rock State Game Refuge on Watts Bar Reservoir, thus establishing another link in the chain of waterfowl feeding areas on the Tennessee River.

Development of the Valley as a wintering ground for wildfowl is holding additional thousands of birds in the region during the hunting season. Canada geese wintering in the Chickamauga-Watts Bar area have doubled their numbers every year since the winter of 1940. Last year, the wintering population exceeded 5,000. An estimated 350 Canada geese and 900 ducks were bagged in that area last season, many more than were ever taken there before. The 30-day open season in the 3,000-acre West Sandy area of Kentucky Reservoir provided 1,800 man-days of hunting. Hunters averaged 18 trips during the season, and 2 ducks per trip. On the opening day alone, hunters bagged over 500 ducks out of the estimated 15,000 ducks in the area.

Land Used in Many Ways

Although agriculture, timber harvesting, recreation, malaria control, and wildlife refuges account for the greater portion of the subsidiary uses of TVA reservoir lands, there are many other uses being made, as illustrated by the approximately 500 miscellaneous land-use agreements in effect between TVA and individuals, firms, and Federal, State, and local agencies at the end of the fiscal year.

As the Valley States have become more proficient in their general resource planning and development activities, their ability to plan the use of TVA reservoir lands has increased accordingly.

This initiative is demonstrated by a proposal from a State conservation department requesting the use of several thousand acres on a mainstream reservoir. Details of the agreement were being worked out at the end of the fiscal year. The land was originally purchased by TVA for storage of water during flood periods. Under State management, by license, the land will continue to serve the water storage need when necessary, but it will also be developed by the State as a waterfowl habitat and shooting area for sportsmen. Public access to the lake will be maintained. Sites for a future recreation boat dock, and for a small TVA construction project planned for the future will be protected. Timber will be harvested on a scientific selective-cutting basis. Domestic wood supplies will be cut from the fallen timber. Experimental plantations of pine and black locust now in the area will be kept. Farmers in the neighborhood will derive cash income from crops they grow there. No cotton will be allowed, because of its tendency to increase erosion, but nearly all other customary local crops will be permitted. Farmers will pay as rent for use of the land a portion of the crop, mostly corn and grain sorghums, which will be left standing in the fields as feed for wildfowl. Clover, alfalfa, and small grain will be encouraged since these not only protect the soil but also winter browse for wildfowl. All summer grains will be followed with winter-cover crops. In addition to the land use activities listed above, the area will continue in its present public use for boating, picnicking, and fishing.

Malaria Incidence Remains Low

TVA's measures to control the malaria hazard along the margins of its reservoirs continued to be highly effective. Analysis of blood samples taken in problem areas along the reservoirs showed that less than one-tenth of one percent of the population was infected, while in 1933 roughly 30 percent of the population had evidence of malaria.

Measures taken to hold down the breeding of malaria carrying mosquitoes include clearing of reservoir shore lines and other preparations before they are filled, fluctuation of water levels during the

breeding season, permanent improvements, such as cutting and filling along the shore line, control of plant growth along the water's edge, and airplane application of DDT larvicide. Water-level management is the "backbone" of the malaria-control program. It has the dual function of managing the main band of plant growth along the reservoir margins and of destroying larvae of the malaria carrying mosquito.

The control of vegetation by this means has reduced the marginal growth invasion to a vertical depth of about 2 feet, as compared with 5 feet or more, and this has made it economical to eliminate permanent breeding places by deepening some shallow places and filling in others.

Certain deep-water plants such as lotus, which cannot be controlled by water-level fluctuations, are controlled by 2,4–D sprays, which have replaced mechanical cutting. Willow, parrots feather, and alligator weed have likewise been controlled with this chemical. Since cotton is extremely sensitive to 2,4–D, application by airplane has been limited to the off-season for cotton and to areas away from cotton fields.

Continued research is carried on to increase the effectiveness of application of aerosols and sprays by airplane. TVA has five malaria-control airplanes. Tests were conducted during the fiscal year with a helicopter, with promising results.

By the end of the fiscal year permanent malaria-control measures had been carried out on 8,500 acres, 44 percent of the area of 19,500 acres proposed for such treatment. The measures included diking off shallow, flat areas from the main body of the lake and providing for drainage during mosquito-breeding season by ditches and pumps, and deepening some shallow areas while filling in others. Such measures eliminate the need for larviciding and vegetative growth control, except under unusual conditions.

The common malaria carrier in the Tennessee Valley is *Anopheles quadrimaculatus*. During 1948, *Anopheles Walkeri*, another species of mosquito capable of transmitting malaria, was found in the Blackwell swamp area near Wheeler reservoir. It was determined that this species persists longer into the cool fall and winter months and studies were commenced to determine its life cycle and habits so that control measures might be initiated when and if necessary.

TVA's malaria-control program has been coordinated with the United States Public Health Service and local and State health organizations. During the year, TVA provided technical advice to the South Carolina Public Service Authority in connection with the Santee-Cooper project and to the United States Corps of Engineers in connection with the Bugg's Island project near Norfolk, Va. TVA collaborated with the United States Public Health Service in preparing a movie and film strip on use of airplanes in larviciding and two

movies on malaria control. It continued to cooperate with the University of Tennessee Medical School at Memphis on research in medical aspects of malaria.

Progress in Stream Sanitation

Conversion of the Tennessee River and its major tributaries into a series of lakes provides the people of the region with diverse benefits, but the full value of the streams can be realized only if the water is of a quality suitable for community and industrial use and for recreation. Therefore stream sanitation is encouraged and assisted by TVA through cooperative efforts with the States and with the industries and municipalities upon whom the primary responsibility rests. TVA makes basic studies of stream pollution, helps correlate facts obtained from extensive sampling, and assists industries and municipalities in planning to meet pollution problems.

Notable progress was made toward reduction of industrial pollution through the action of several plants. Industries have shown increased interest in reducing the wastes poured into the streams, and TVA's assistance has been asked in working out plans for waste reduction and in making checks to determine the need for, or effectiveness, of sanitation measures.

At Harriman, the Mead Corp. plant installed a new paper machine which permits recirculation of the "white water," thereby reducing the volume of such waste substantially. In addition, it carries out temporary measures at periods of low flow. Another Mead plant at Kingsport put a new kiln into service which burns 75 tons daily of sludge formerly discharged into the Holston River. It was also installing equipment for burning black ash at the rate of 25 tons daily.

Assistance of TVA was asked in studying the pollution problems of two plants, the North American Rayon Corp. and the American Bemberg Corp., by helping to interpret data already gathered and suggesting future work. The two plants have been cooperating, with the North American laboratory handling stream pollution investigations for both plants, which was regarded as encouraging since the problems in the Watauga River below Elizabethton cannot be solved by either plant independently. Initially, efforts were to be made to discover what materials in the waste hinder biological action in the Watauga River and thus retard natural stream purification.

TVA also was cooperating with the Tennessee Copper Co. in planning for waste disposal and reduction of acidity in the Ocoee River. It was also assisting in an intensive study of the effects of pollution at Asheville in cooperation with the North Carolina Stream Sanitation and Conservation Committee.

Various cities took steps toward initiating or improving sewage

treatment. Citizens of Bristol, Tenn., and Bristol, Va., approved bond issues of nearly $3,500,000 for joint construction of collecting sewers and a sewage-treatment plant. Knoxville completed preliminary plans for a sewage-treatment plant, but a bond issue has not been submitted for referendum. Plans have been made by Chattanooga for a screening, with primary treatment to be considered for the future. Asheville requested TVA to assist in preparing a municipal waste-disposal planning report.

Purchases of Land

During the year TVA acquired in fee or obtained flowage or highway easements on 587 tracts consisting of 5,111 acres at a total cost of $1,233,646, or an average cost of $241 per acre, including improvements. Transmission line easements were acquired over 2,149 tracts for a distance of 450 miles at a total cost of $250,055. Miscellaneous rights were acquired in connection with 1,005 tracts at a total cost of $997,794.

Of the total acreage acquired by TVA to date, exclusive of property acquired by transfer or from public utility companies, 9.87 percent has been obtained as a result of condemnation proceedings, of which 6.19 percent represents the contested cases and 3.68 percent represents noncontested cases, which generally were filed for title reasons.

Sales of TVA Lands and Villages

In order to determine what lands TVA needs to retain in order to carry on its activities under the TVA Act, to assure public access to TVA lakes, and for other public purposes, TVA has for the past several years been reviewing its reservoir lands. Land not needed for public purposes is sold.

A total of 67,984 acres have been sold at public auction in accordance with either section 31 or section 4 (k) of the TVA Act for $5,942,387. During the fiscal year, 617 tracts containing 13,728 acres were sold for $1,369,003.

Among the properties transferred to the TVA in 1933 under the TVA Act were three villages located on the Government reservation at Wilson Dam. They were constructed by the War Department when the chemical plants and Wilson Dam were constructed, beginning in 1918, and have been occupied since 1933 by TVA employees. The villages were disposed of during the year in line with TVA's policy to dispose of employee housing as soon as it has served its purpose, usually for construction workers at locations where there was insufficient housing. TVA retained the land in Villages No. 2 and 3, but sold both land and buildings in Village No. 1.

The 238 houses and 37 garage buildings in Villages 2 and 3 were sold at public auction for a consideration of $194,250, representing an increase of $63,460 above the minimum acceptable price.

In order to avoid a decrease in the number of housing units in the Muscle Shoals area and also to provide some measure of protection to the tenants occupying these buildings, the terms of sale provided that the houses in these two villages should be relocated in the immediate vicinity in accordance with local zoning and planning requirements. The terms also assured the occupant of any specific house first option to purchase after relocation, price not to exceed costs of purchase, removal, and relocation plus 15 percent.

Included in the sale of Village 1 were 80 houses and lots, 7 residential acreage tracts, 1 business site, 5 industrial tracts, 3 farm tracts, 17 residential lots, and a garage building. Total consideration for this property amounted to $567,920. By agreement the city of Sheffield, Ala., immediately assumed responsibility and control of the area composing Village 1, and the city was instrumental in securing the introduction in the State Legislature of an act for incorporating the village within the city limits.

III. Progress on the Land

The development of the river system is a productive enterprise only as it contributes to the well-being and efficiency of the people of the Valley in putting the resources of the land to work. Curbing of floods protects some of the productive assets of the area and makes possible the more intensive development of some of the lands of the region; the waterway provides a new, economical avenue for commerce with other regions and widens the market for products of the Valley; the generating plants provide an efficient, economical, and flexible supply of power for developing and processing the region's natural resources of farm lands, forests and minerals.

The Tennessee Valley watershed, a region of 41,000 square miles, includes mountainous and hill-and-valley areas, rolling lands, and some fairly level bottom lands. Almost 17,000,000, or 65 percent, of its 26,000,000 acres are in farms. The area of open farm land per capita is about half that for the United States.

Like other regions, the Tennessee Valley has its strengths and weaknesses, its advantages and disadvantages. The soils of the Valley vary greatly in composition, but a great many of them are highly acid, and are deficient in phosphorus and other plant nutrients. On the other hand, the soils respond well to good management and with the addition of missing fertility elements they produce well. The climate, with ample rainfall, provides a long growing season. Erosion and a decline in natural soil fertility, especially on sloping lands, have resulted from the combination of heavy rainfall, moderate climate, and repeated row cropping, but these are being overcome by the expansion of better agricultural practices.

Forest growth, including farm woodlands, covers 55 percent of the Valley. Originally, the entire region was heavily forested. The remaining forest lands have been mostly cut-over and generally are poorly restocked. But the range of valuable tree species is unusually large, including more than 100 commercial varieties. The favorable climate and growing season plus the introduction of modern forest management methods promises to make the forest lands an increasingly important economic asset and more effective in watershed protection.

The minerals found in the region, with the exception of coal, are generally in small, scattered deposits, and sometimes of low grade.

Yet many of them are valuable and some of them of strategic importance; they provide the opportunity for many small, but nevertheless profitable operations.

The Region Makes Progress

The people of the Valley cannot control the rainfall, they cannot change the temperature range, and they cannot significantly alter the topography of the land. But they can adjust farming systems, improve soils, adopt scientific forestry practices, and develop varied sources of income by taking advantage of the good points in their climatic and geographic setting. They are doing so. They are restoring and increasing the value and potential benefits of the natural resources.

This is a movement in which TVA, the Valley residents, and the State and local governments and institutions pool their efforts. Success of the integrated approach appears in the growing number of local industries processing raw materials into finished products, in increased crop yields, in diversification of farming, in decreasing losses from forest fires, erosion, and inefficient methods.

Fertilizers for Agriculture

One of TVA's tasks is research and experimentation to develop improved fertilizers, particularly soil minerals which are essential to the Valley's soil-and-water-conservation activities and are of great significance to the agricultural development of other regions as well. These researches, which may cover several phases—laboratory tests, pilot-plant operation, and finally full-scale experimental plant production—are carried on at the chemical plants near Wilson Dam. The plants serve a dual purpose, for they are available in case of need for production of munitions for national defense. Although during the last fiscal year, TVA carried on no major munitions research, its facilities have been used for that purpose in the past and are available at any time.

TVA, in its early days, addressed itself first to improvements in phosphate technology, because lack of phosphorus is the chief limiting factor in improving the fertility of many soils, and this is largely true of the Tennessee Valley region. However, its explorations include development of processes for production of fertilizers containing other plant nutrients, either singly or in combination. During World War II, it was instrumental in adapting ammonium nitrate, produced as an ingredient of munitions, for agricultural use. Other processes under study, to be briefly described later, would produce combinations including nitrogen, phosphorus, and potassium, the three major plant nutrients.

TVA and Fertilizer Technology

Research and experimental production at the TVA chemical plant at Muscle Shoals have several objectives. One is the development of improved fertilizers, particularly soil minerals needed in the Valley's soil-and-water-conservation activities, including improvement of the process by which the materials are produced. A second objective is keying the work at the plants to TVA's national responsibilities, for other regions of the Nation have acute need for improved and more economical fertilizers. In this important field of scientific research, TVA maintains contacts with United States Department of Agriculture fertilizer technicians to insure dovetailing of the work of the two agencies. A third objective is the experimental production of materials on a plant scale to perfect the processes and to produce quantities of the materials for large-scale test demonstrations, and to assist in meeting the current shortage of fertilizers. A fourth objective is to encourage the adoption of new processes, in whole or in part, by private industry in order that the improved fertilizers will be more widely available to meet the needs of agriculture and soil conservation. And a fifth objective is maintaining the chemical plant facilities as a national-defense asset.

Munitions

TVA's phosphate and nitrogen plants double as munitions producers in case of need, in accordance with the TVA Act which specifies TVA's national-defense responsibilities. TVA continues to produce elemental phosphorus as a separate step in its concentrated-fertilizer process so that the plant is ready for immediate conversion to munitions production. Many of the improvements in the phosphate and nitrogen plants made during the year have dual value in producing fertilizer or munitions. TVA's improved processes using low-grade phosphate and its improved mining and washing processes help prolong the life of the Tennessee reserves as a military asset. Most of the industrial installations producing elemental phosphorus draw upon the dwindling Tennessee reserves.

Phases of Development

Development of a new fertilizer or an improved process proceeds through several phases. First may come background study concerning the basic chemistry involved. Exploratory laboratory research follows to determine whether proposed processes are promising enough to warrant pilot plant investigations. Pilot plant operations which prove technically feasible and economically promising go on into large-scale plant operations when these are required to improve processes further and to demonstrate feasibility in normal plant operations.

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Phosphate Technology

TVA's interest in new developments in phosphate technology runs from initial mining operations through the final product. During the year TVA began work on application to phosphate ores from the far West and Florida of two methods of preparing materials for furnace charges. The two methods were developed with Tennessee phosphate sands and matrix. One method is pelletizing, in which the sands are tumbled with clay or matrix in a kiln to form pellets. A large-scale pelletizing shaft-kiln plant was being designed to demonstrate the process. New large-scale briquetting equipment, which will press the material into lumps, was under construction.

At the close of the fiscal year, TVA was designing a large-scale rotating electric furnace, based upon data obtained in pilot-plant operations in the 1948 fiscal year. The pilot-plant operations indicated that the slowly rotating furnace could, to a considerable extent, use phosphate sands without pelletizing, briquetting, or other agglomeration; that it used less power than the conventional furnace; and that more even distribution of heat reduced wear on the furnace lining. Several large private concerns have been following the development with interest.

Two major problems in connection with a previously known process for making phosphoric acid suitable for fertilizer manufacture by catalytic oxidation of phosphorus with steam were solved in small pilot plant operations during the year. The work involved finding a satisfactory catalyst and construction materials which would resist corrosion. This phosphoric acid process also produces hydrogen, an element essential for ammonia synthesis, as a byproduct; hence it is expected to have special value in areas, as in the western phosphate fields, where ammonia synthesis facilities can be built in conjunction with electric-furnace phosphorus production, particularly where natural gas is not available as a raw material for nitrogenous fertilizers.

Studies were initiated to improve the so-called "wet process" for producing phosphoric acid by treating phosphate rock with sulfuric acid. Small-scale experiments indicated that it should be feasible to use cheaper and more abundant low-grade phosphate. Studies were being conducted on the use of phosphate matrix as it comes from the mines and on the recovery of sulfuric acid from the byproduct calcium sulphate resulting from the process.

Several improvements were made to increase efficiency and assure better quality control in the TVA process for making concentrated superphosphate (45 to 48 percent P_2O_5). New pulverizers and a new conveying system were installed, and a new acid-metering and piping system, to regulate acid flow from tank to mixer, was put into use.

At the end of the year, TVA had practically completed a new calcium metaphosphate furnace unit in which unagglomerated fine phos-

phate may be used for a large part of the charge, thus reducing the cost and improving chemical control of the product. The new furnace will be used for further development and demonstration of the calcium metaphosphate process in large-scale equipment. It will produce larger quantities of the material, containing about 61 percent P_2O_5, for testing in farm use than have been available from pilot-plant operations. Improvement in methods of conditioning the material were also being sought.

At TVA's plant in middle Tennessee, efforts were directed during the year toward solving the most difficult remaining problem in the TVA-developed process for producing fused tricalcium phosphate, that of corrosion of the shells of the fusion furnaces. Installation of copper cooling coils and use of carbon paste to line the lower part of the furnace both were found to give generally satisfactory results; TVA is rebuilding the second furnace to incorporate the improvements.

A plant-scale demonstration unit for the recovery of fluorine, which is liberated in one form or another in most phosphate-manufacturing processes, was placed in operation at the fused tricalcium phosphate plant toward the end of the year. The process, a relatively simple one in which waste gases from the furnaces are passed through a tower packed with lump limestone, was tested in pilot-plant operation last year. The fluorine is recovered as calcium fluoride, which promises to be a salable byproduct in view of the expanded demand for fluorine compounds.

TVA also completed pilot-plant studies on defluorination of Florida and western-rock phosphate. Neither was as easy to defluorinate as Tennessee phosphate. However, comparable results were obtained by: (1) Adding small amounts of phosphoric acid to the furnace charges; (2) using pelletized charges of Florida phosphate and Tennessee matrix; and (3) using pelletized charges of Florida or western phosphate and high-silica clay.

Nitrogen Processes

A continuous vacuum crystalization process for producing ammonium nitrate was placed in test-operation during the year, the first large-scale application of the process in the United States. The process essentially eliminates the hazard of explosion present in the two common methods of graining ammonium nitrate, since it is carried on at lower temperatures. It is also more economical than the batch-graining method it will replace at Muscle Shoals and promises to produce a fertilizer of higher nitrogen content. The process will produce either fertilizer or munitions grade material. Adequate control of crystal size at good production rates was being sought at the end of the year through adaptation of equipment.

Plans were under way to convert the ammonia plant to use natural gas instead of coke as a raw material. Use of natural gas as a source of hydrogen, together with some plant changes, is expected to increase production capacity and reduce costs.

Phosphate-Nitrogen Processes

TVA continued study during the year on a group of processes for producing fertilizer materials containing both phosphate and nitrogen. Potash can be added during the processing, so that the final product contains all three of the major fertilizer components, nitrogen, phosphate, and potash. Development of such processes is particularly timely since large quantities of nitric acid and ammonia are being produced in fixed nitrogen plants built during the war.

Pilot plant studies during the year were successful in producing one such material, dicalcium nitraphosphate, containing typically 17 percent nitrogen and 23 percent P_2O_5. A similar project using sulfuric instead of phosphoric acid was tried in pilot plant operations. The process produces material containing about 14 percent each of nitrogen and phosphate and may prove more economical than the process using phosphoric acid. A simple process in which rock phosphate is treated with nitric acid and the product ammoniated, dried, and conditioned for use was also studied during the year, and work was continuing to develop a conditioning process to prevent caking of the material, called ammoniated nitric superphosphate and containing about 15 percent each of nitrogen and phosphate.

Five articles were published in technical journals. Chemical Engineering Series Reports No. 1 and No. 2 were issued, and the work was reviewed in a popularly written pamphlet, "Soil, People, and Fertilizer Technology."

Production of Fertilizer Materials

TVA's plant-scale operations, the final step in its development of new materials and new processes, produced considerable quantities of fertilizers and intermediate products. The fertilizers were used in controlled tests or in the farm test-demonstration activities, or were sold for use in soil- and water-conserving farming operations.

Phosphoric acid equivalent to about 68,900 tons of P_2O_5 was produced, about 12 percent more than the year before. Concentrated superphosphate production was more than 158,700 tons, up 4 percent. About 3,500 tons of calcium metaphosphate was produced in a small plant unit. Production of fused tricalcium phosphate in the plants at Columbia, Tenn., amounted to 15,200 tons. More than 36,600 tons of dicalcium phosphate was produced. The ammonia plant produced 66,200 tons, above design capacity of the plant but less than the year

before, and most of it was used in production of ammonium nitrate fertilizer, which totaled more than 151,200 tons. Nearly 6,000 tons of ammonium nitrate fertilizer was exported under the European Recovery plan.

TVA Developments Aid Industry

TVA encourages the use of its new or improved processes by private industry in a number of ways—welcoming representatives of fertilizer and allied industries to its plants to observe operations and designs; giving direct assistance through consultation, advice, loan of drawings, and running tests; and publication and distribution of technical articles and reports embodying TVA findings. In this manner, TVA over the past several years has been making an important contribution to the advancement of fertilizer technology.

Two companies were licensed during the year to make use of TVA's continuous mixing process for producing concentrated superphosphate. The licenses were on a royalty-free, nonexclusive basis. The Sturtevant Mill Co., Boston, Mass., is interested in commercial manufacture of the mixing equipment and the Tennessee Corp. of New York plans to use it in its superphosphate plants. The process combines phosphoric acid and ground phosphate more efficiently and economically than the batch-mixing process. A license was granted the Harshaw Chemical Co., Cleveland, Ohio, for use of a patented TVA process in the manufacture of a water-gas conversion catalyst for synthetic ammonia production. This was one of two developments by TVA during World War II which represented economies over previous methods of catalyst manufacture. Both give exceptionally satisfactory service. Several phosphoric acid producers are using equipment based on TVA developments after having studied the work at Muscle Shoals.

Nearly 400 visitors at the Muscle Shoals plant during the year sought information on technical aspects of fertilizer research or related subjects. Many were engineers or technicians seeking definite information for use in plant operation or construction of new plants. In some cases, engineers made routine visits to keep abreast of development. In addition, nearly 1,500 nontechnical visitors, mostly in large groups, visited the plants.

Among the companies whose representatives were given information and assistance of one kind or another were:

International Minerals and Chemical Corp., Monsanto Chemical Co., Westvaco Chemical Division of Food Machinery and Chemical Corp., Montana Power Co., Stuart Oxygen Co., Utah Power and Light Co., Allied Chemical and Dye Corp., Phillips Petroleum Co., Electric Reduction Co. of Canada., Precipitation Co. of Canada, Ltd.,

Mississippi Chemical Corp., Shell Chemical Corp., Electrolytic Zinc Co. of Australia, Lion Oil Co., Spencer Chemical Co., E. I. du Pont de Nemours & Co., Aluminum Co. of America, National Fertilizers, Ltd. (India), Pennsylvania Salt Manufacturing Co., Reynolds Metals Co., and Victor Chemical Works.

Fertilizers and Soil Management

The best fertilizer made is a loss unless it is properly used in agriculture in terms of over-all farm operations, including not only increased production but the conservation of soil and water as continuing assets of regional and national economy. Increased production is only a temporary gain if it results in soil depletion.

TVA, the land-grant colleges, the United States Department of Agriculture, and farmers themselves cooperate in testing and demonstrating the new fertilizers produced at Wilson Dam in relation to all the other aspects of farming. In this process, three steps are essential. A starting point is gathering basic data about the agricultural resources of the Valley. A second is the testing of new fertilizers under controlled conditions in laboratories, greenhouses, and field plots. The culminating step is testing and demonstrating the use of the new materials in practical farm operations in conjunction with other improved farm management practices which further watershed protection.

These related practices add up, in many cases, to a complete shift in emphasis from row-crop farming to livestock, pasture, and small grain production. This is accomplished through the test-demonstration program, which acquaints farmers with the use of the new fertilizers and provides them with the knowledge needed to achieve soil and water conservation as a basis for a healthy agricultural economy.

The Valley has a wide variety of soils, differing in the agricultural uses to which they are suited and in the kind of management required for soil conservation and improvement. In order to classify these soils, the TVA, U. S. D. A., and the land-grant colleges are engaged in a systematic soil survey in which the soils are mapped and their suitability to different crops, grasses, and trees indicated. At June 30, 1949, about 70 percent of the 41,000 square miles of the Valley—lying in 65 counties in the seven Valley States—had been mapped. An additional 1,200 square miles lying just outside the watershed had also been mapped.

Controlled Investigations

State experiment stations cooperate with TVA by conducting controlled investigations seeking the answers to a variety of questions. Among them are crop response to various types of fertilizers and to

different rates of application, and effects of fertilization on the nutritive value of forage crops, the residual effects of phosphate fertilizers several years after application, and so on.

Since TVA phosphate fertilizers are used on pastures and other close-growing plants, recent experiments have been designed to determine the fertility requirements of pasture and forage crops for some of the important soil regions of the Valley. Some of the new plants which appear promising in year-round grazing systems include sericea, lespedeza, Ladino clover, and the fescue grasses. A number of TVA's cooperative projects are directed toward determining the fertility requirements of these plants.

Calcium metaphosphate, fused tricalcium phosphate, and dicalcium phosphate received considerable attention in the field experiments on phosphorus carriers during the past year. A 7-year experiment on Bedford silt loam in Indiana showed calcium metaphosphate to be as effective as ordinary superphosphate in increasing the yields of corn, wheat, and hay. Comparative increases over a no-phosphate treatment were: From calcium metaphosphate, 9.6 bushels of corn, 13.7 bushels of wheat, and 1,241 pounds of hay; from ordinary superphosphate, 8.7 bushels of corn, 7.0 bushels of wheat, and 1,107 pounds of hay.

The effects of fertilization upon the chemical composition of several forage plants were measured in experiments conducted in several of the Valley States. Virginia workers showed that heavy phosphorus fertilization increased the phosphorus content of white clover as much as 71 percent. Lime application resulted in increased nitrogen content of legumes, but had only variable effects on other chemical constituents measured.

A report was completed by the Virginia experiment station covering crop response to fertilizers in research carried on from 1891 to 1947. A similar report was made by Alabama last year and eventually all seven Valley State experiment stations will report, and the results will be correlated by TVA. As examples of information contained in the Virginia report, it was stated that wheat yields on the basis of 228 tests increased 36 percent as a result of phosphating, corn increased only 12 percent, but red clover-timothy hay increased 46 percent. The report also indicated that residual phosphorus from 175 pounds of P_2O_5 applied over 5 years resulted in increased yields of corn, wheat, and hay 25 years later. It was estimated that in 38 years, the equivalent of 50 percent of the 175 pounds of fertilizer applied was recovered in the harvested crops.

Test-Demonstrations Aid Farmers

Test-demonstrations on operating farms provide a means by which farmers learn what the new TVA fertilizers can do in achieving sound

management systems. Besides the farmers who cooperate directly in them, the test-demonstrations provide the opportunity for many other farm operators to follow and study the practices and the results and apply the same materials and methods to their own farming.

Test-demonstrations are of two types: unit and area. Unit test-demonstration farms are selected by the farmers of a community on the basis of representativeness of size, soils, type of farming, and tenure. Test-demonstration farmers with the help of the county agent, work out farm plans which may include rotation of crops, increased livestock production, fertilization schedules, and other practices fitted to the individual farms. The test-demonstration farmers follow such plans, taking the risks and making the expenditures involved including, in the later stages, partial payment for the TVA fertilizers used, and keeping comprehensive records by which the results may be judged. Area test-demonstrations include groups of farmers organized in communities or small watersheds, usually around one or more unit farms. The state agricultural extension services administer the test-demonstration activities with county agents assisting the test-demonstrators and encouraging application of the methods on surrounding farms.

Fertilizer Payment Plan Changed

During the fiscal year 1949, TVA provided experimental fertilizers under a graduated-payment plan which provided that the test-demonstrators would receive fertilizers for payment only of freight and handling charges for the first applications on their fields. For the second application, they paid 50 percent of the established price of the fertilizers, and for the third and subsequent treatments they paid full price. A limited number of special study farms paid 50 percent of the established price as long as they continued the activity.

Experience revealed that the plan imposed too heavy a load on field personnel and did not permit the farmer enough flexibility in adjusting his operating methods. Hence a new plan, worked out by the TVA and the agricultural extension services, was placed in operation with the beginning of the new fiscal year.

The field-by-field method of calculating payments was abandoned in favor of basing the payments on the length of time in which the farmers participate in the activity. During the first 3 years, fertilizer will be provided for freight and handling charges only. In the next period, not to exceed 7 years, the farmers will pay 50 percent of the established price of the fertilizer in addition to freight and handling costs. Thereafter, the farmer may continue as a unit test-demonstrator but will pay full price for fertilizer, either from TVA or commercial sources. Area test-demonstration farmers pay 50 percent of the price of fertilizer for a period not to exceed 8 years, plus freight

and handling charges. Modification of these arrangements will apply to test-demonstration farms outside the Valley and to a limited number of special study farms.

Number of Test Demonstrations

Since the test-demonstration activity was begun in 1935, about 27,000 unit farms and 784 areas containing about 38,500 farms have participated, making a total of 65,500 test-demonstration farms. Of these, 1,195 entered the program during the fiscal year 1949, including 636 unit test-demonstration farms and 559 area farms. During 1949, 4,564 unit and 2,848 area farms received test-demonstration materials under the partial payment plan.

The success of the test-demonstration activities is reflected in better farming practices on the test-demonstration farms themselves and in the adoption by other farmers of improved farm management practices thus demonstrated, including increased use of soil minerals, decreased row crop acreages and increased acreages of improved permanent pasture, legumes, and small grains, greater production per acre, growth of livestock farming, and so on. Such practices lead to more income for the farmer, conservation of the soil resource, and more diversified and stable agriculture.

Farm Cooperatives Help

Farm cooperative organizations distribute TVA fertilizers to test-demonstration farmers in the Tennessee Valley and cooperate with the land-grant colleges and TVA in education for agricultural development. The cooperatives in the Valley, as well as many of those outside the Valley, also sell fertilizer produced in TVA's plant-scale operations. Outside the Valley, distribution of test-demonstration materials is handled by test-demonstration associations or committees which in most cases are not affiliated with cooperative organizations distributing TVA sales materials.

In the fiscal year 1949, nearly 27,000 tons of TVA phosphatic materials—4,127 tons of concentrated superphosphate, 4,712 tons of calcium metaphosphate, and 18,092 tons of fused tricalcium phosphate—were distributed for test-demonstration use. Another 405 tons of fertilizer materials were provided to agricultural experiment stations for controlled tests to determine efficiency of the products for crop production.

TVA sold 151,000 tons of ammonium nitrate fertilizer and 145,000 tons of concentrated superphosphate during the fiscal year, thus assisting in meeting the shortage of fertilizer materials in the country. The fertilizers were sold chiefly through cooperatives which are conducting educational programs to assist their members in soil- and water-conservation practices. Small amounts of TVA fertilizers were also

sold to other Governmental agencies and for export in accordance with national foreign policy. TVA also sold about 108,000 tons of calcium silicate slag, a byproduct of electric furnace operations which has proved of value as a liming material and soil conditioner, and 37,000 tons of dicalcium phosphate to help meet a continuing shortage of mineral supplements for animal feeds.

During the fiscal year 1949, sales of ammonium nitrate and concentrated superphosphate, as well as distribution of test-demonstration materials, were generally handled in the Valley under direct contracts between the TVA and the Valley cooperatives. In Alabama, Tennessee Valley Cooperatives, Inc., chose to obtain the TVA materials through Associated Cooperatives, Inc. Under all the distribution contracts, the cooperatives assume responsibility for educational activities designed to achieve uses of TVA fertilizers in accordancec with recommendations of the land-grant colleges and with TVA objectives of soil conservation and watershed protection.

Many of the cooperatives initially confined their business activities to distribution of TVA test-demonstration fertilizers but have now added a variety of services to help farmers make desirable adjustments in farming operations. Such services included purchase and distribution of commercial fertilizers, feed, seeds, insecticides, and farm implements; processing of fertilizers, seeds, and feeds; and marketing of farm products. For example, one federation of cooperatives has set up a seed-testing laboratory; two farmer-owned fertilizer-mixing plants are in operation; and one of the most modern feed mills in the South is owned and operated by a cooperative in the Valley.

TVA, through a small staff, assists the cooperatives in accounting and other operating and administrative problems, as well as in educational programs, in order to increase their effectiveness in helping bring about better use of agricultural resources.

Measurement of Test-Demonstration Results

Reports from the various State extension services which supervise the test demonstrations have shown the results obtained in soil conservation and in improvements in agricultural production and income on the test-demonstration farms and in test-demonstration communities. They have indicated also the extent to which improved farm practices have spread as a result of the test demonstrations, which have themselves generally been confined to relatively small numbers of farms and small areas.

In the last fiscal year, TVA made a survey on a broader scale to determine, on the basis of existing records from several sources, the impact which the test-demonstration program has had generally over a wider area, the State of Tennessee. This State provided the best basis for comparison for several reasons. Sixty-three of the counties

within the Tennessee Valley watershed are in Tennessee, while 32 Tennessee counties lie outside the Valley. The test-demonstration activities in Tennessee are confined almost exclusively to the Valley counties in Tennessee, whereas this is true in no other Tennessee Valley State. And finally, parts of five of the general soil and agricultural regions of the State are in both Valley and non-Valley counties. In view of these facts, comparison of data for the two regions is helpful in determining the relative spread of conservation practices.

Phosphates are generally applied to enable growth of soil-conserving crops, so that the amounts used by farmers are significant as a measure of conservation practices. In the fiscal year 1948, farmers in the Valley portion of Tennessee used an average 502 pounds of P_2O_5 per 100 acres of open farm land, of which 398 pounds was purchased commercially (including sales of TVA materials), and 104 pounds was provided by TVA in the test-demonstration program. This was more than double the 232 pounds of P_2O_5 purchased per 100 acres of open farm land in the non-Valley sections of the State. These data came from records of the Tennessee State Department of Agriculture and of TVA.

Further evidence of soil conservation through addition of soil minerals is shown by data from Production and Marketing Administration annual reports for 1936 and 1947. In 1936, both the Valley and non-Valley counties used negligible amounts of phosphates under the P. and M. A. program. In 1947, the Valley counties used 523 pounds of P_2O_5 per 100 acres of open farm land, as compared with 14 in 1936. In the non-Valley counties, use of phosphates increased from 9 to 373 pounds. Thus the Valley counties increased the use of phosphate by 145 pounds more per 100 acres of open land than the non-Valley counties. This was at a time when a reduction of 45 pounds P_2O_5 per 100 acres was being made in test-demonstration materials provided, which indicated a definite acceleration in spread of fertilization practices from test-demonstration to other farms.

Use of lime is another requirement for good soil management in the Valley region. Reports of the Production and Marketing Administration show that in the Valley counties, use of lime between 1936 and 1947 increased from 1.9 to 8.9 tons per 100 acres of open land, an increase of 7 tons, while the change in non-Valley counties was 5.9 tons, from 1.1 tons to 7 tons. The increase was about a ton greater in the Valley counties than in the non-Valley counties.

Under the soil, climatic, and agricultural conditions prevailing in Tennessee, shifts in land use from row crops to soil-conserving crops are significant soil and water conserving practices. In the Valley counties, row crops were reduced between 1935 and 1945 by nearly 6 acres per 100 acres of open farm land, from 28.3 to 22.6 acres, whereas the reduction in the non-Valley counties was less than 5 acres, from

37.4 to 32.5 acres. At the same time, the proportionate acreage of soil-conserving crops (hay and small grain) increased by more than 4 acres in the Valley counties (from 18 to 22.3 acres), compared with a 1.7-acre increase in non-Valley counties (from 13.8 to 15.5 acres). The same trend was shown with respect to soil-conserving legumes (alfalfa and clovers), where the increase was more than 4 acres for the Valley counties (from 8.7 to 12.8) as compared with less than 1½ (from 8.4 to 9.8) for the non-Valley counties. The amount of idle or fallow land also decreased about twice as much in the Valley as in the non-Valley counties—2.3 acres as compared with 1.2 acres.

Since soil conservation practices must be carried out by practical farmers, they must be compatible with efficient farm management systems. The growth in acreage of soil-conserving crops such as legumes, treated pastures, and hays make increased livestock production a part of the soil-conservation pattern. Between 1935 and 1945, the number of cows and calves per 100 acres of open farm land increased from 11.3 to 13.2 in the Valley counties, as compared with an increase from 9.6 to 10.8 in non-Valley counties. The increase, therefore, was about 1½ to 1 in favor of the Valley counties.

The number of cows milked per 100 acres of open farm land remained about the same in each of the areas (5 in the Valley, 4 in the non-Valley section), but milk production increased much more markedly in the Valley section of the State. The total gallons of milk produced per 100 acres of open farm land increased by 592 gallons in the Valley, from 1,697 to 2,289 gallons as compared with an increase of only 89 gallons in the non-Valley section, from 1,495 to 1,584. Milk production per cow increased by 84 gallons in the Valley section per year, as compared with 61 gallons in the non-Valley counties.

Since cattle production is closely associated with sod-crop production, these Tennessee data indicate that the increase in sod-crop acreage is being used to an economic advantage in livestock production, and to a greater extent in the Valley.

Comparisons for Seven Valley States

Comparisons of Valley and non-Valley counties for six of the seven Valley States are of considerably less significance than those in Tennessee, for several reasons. Valley counties of four of the States—Alabama, Georgia, North Carolina, and Virginia—are generally hilly or mountainous, whereas the non-Valley sections are mostly on the plains of Piedmont and coastal lowlands. Agricultural and climatic conditions differ accordingly. The Valley areas of the other two States—Kentucky and Mississippi—likewise are not representative of the States as a whole. Comparisons of crop and land use changes, therefore, are of little help. Moreover, both Valley and non-Valley

areas have test-demonstration activities, although the test-demonstration farms are more concentrated in the Valley.

However, despite these drawbacks, a comparison of use of P_2O_5 and limestone for soil improvement in the Valley and non-Valley portions of the seven States is considered significant.

Farmers in the Valley counties, over the period 1936 to 1945, used 1.40 tons of P_2O_5 per 100 acres of open farm land, as compared with 0.86 ton in the non-Valley counties. They also used nearly 54 tons of lime, as compared with 33 tons used per 100 acres of open farm land in the non-Valley sections. The figures covered 125 Valley counties and 598 non-Valley counties in the seven States.

Trends in Valley Counties

Figures compiled for 114 Valley counties show very marked changes in phosphate and lime use between 1935 and 1947. In 1935, farmers in these counties used 2,568 pounds of lime for each 100 acres of open farm land. In 1947, they used 15,760 pounds, or six times as much.

The farmers in these counties for which data were available increased their use of P_2O_5 from 44 pounds per 100 acres of open farm land to 544 pounds. Use of phosphate in 1947 was more than 12 times that in 1935.

Figures for 51 Valley counties showed that the acreage of improved, treated, and seeded pastures increased from about 132,000 to more than 628,000, or nearly five times, between 1935 and 1947. In the same counties, the acreage of winter cover crops multiplied four times, from 172,000 to more than 684,000 acres.

Mechanical Measures for Soil Conservation

Adequate fertilization and liming, in order to establish a protective and productive vegetative cover, is the most important step of soil conservation in the Tennessee Valley in view of the topographic, climatic, and soil conditions in the Valley. In some places, the terrain is too steep for effective terracing. In the Valley counties of Virginia, the adjustments in fertilization and cropping in relation to the soils has progressed to the point where terracing is not needed in most places.

However, supplementary engineering measures such as terracing, strip-cropping, and contour tillage have been used extensively in many areas. In 114 counties of the Valley for which data are available, the number of miles of terraces has increased from 11,415 in 1935 to nearly 128,000 in 1947. In the Valley counties of Georgia, North Carolina, and Virginia, the number of acres strip-cropped increased from about 6,200 to 17,600.

While no data have been collected, observation of agricultural practices indicates that contour tillage is practiced on practically all

of the more than 1,000,000 acres that have been terraced and strip-cropped. Where such soils are cultivated at all, contour plowing has been generally adopted on most of the hilly and steep lands and much of the unterraced undulating and rolling lands.

The Forest Resources

A survey completed during the fiscal year showed that the Valley forests, although heavily cut over, subject to fires, and poorly managed in the past, were still the basis for a more than $200,000,000 annual business in the Valley in 1946. The 5,600 sawmills in the Valley counties produced 1,400,000,000 board feet of lumber and ties valued at $62,000,000, provided the equivalent of 16,000 full-time jobs, and paid $21,000,000 in wages. Some 1,200 other forest products plants produced more than $190,000,000 in pulp and paper, furniture, millwork, flooring, dressed lumber, handles, tannin, excelsior, boats, shuttles, etc. They provided the equivalent of 27,000 full-time jobs and paid more than $44,000,000 in wages. They used about $31,000,000 worth of supplies other than wood.

With adequate protection from fires, with modern forest management, encouragement of the best growing species of trees, and full utilization of forest products, it is estimated that the annual regional forest income could be quadrupled. Moreover, the forests and woodlands are important in watershed protection. They maintain the soil against erosion and capture rainfall for the use of growing plants and to maintain the water table.

TVA's role in forest development, as a part of its over-all resources responsibilities, has been to help assemble the facts concerning the forest resource potentialities and to cooperate with Valley residents in using the facts to apply the principles of modern forest management to improve the forest resource.

Fire Protection Aids Forest Development

Emphasis has been placed upon protection of forests and woodlands against fires. In addition to the destruction they cause, fires discourage the expansion of modern forest management. Forest and woodland owners naturally are reluctant to embark on forest programs while a serious danger exists that the work of a decade may be wiped out by a single blaze.

Organized fire control has been extended to 42 Valley counties since 1933, increasing the protected area by nearly 5,600,000 acres. Of the 14,000,000 acres of forest land in the Valley, near 10,000,000, or about 70 percent, now has organized protection.

TVA cooperates with State and local forestry agencies and with forest land owners in organizing protection. A great deal of emphasis is placed upon fire prevention. In many instances, the financial aid which TVA has given in the initial stages of organizing

protection in particular areas has provided the margin needed for intensive education on fire prevention. As projects become established and operating, both in fire prevention and suppression, TVA discontinues financial assistance, although it continues to provide technical aid.

Forest Management Demonstrations

The most convincing argument for good management of forests and woodlands is actual demonstration, on a practical scale, of the benefits of selective cutting, good care, and protection as proof of the economic soundness of sustained-yield forestry. Such demonstrations have been developed by the TVA, with the cooperation of public agencies and private landowners, on large forest tracts, on farm woodlands, and on forest holdings of educational institutions and municipalities.

About 40 percent of the forest lands in the Valley is on farms. Thirty-seven new farm woodland management demonstrations, involving more than 3,000 acres, were added during the year to the 229 previously established. Demonstrations are now located in 71 counties on more than 20,000 acres of farm woodlands. State extension service personnel prepared forestry plans for 289 unit test-demonstration farms in the Valley as a part of complete farm planning. TVA foresters assisted extension services in the preparation of 59 more. At the end of the year, nearly 50,000 wooded acres on 874 Valley unit test-demonstration farms were covered by forestry plans.

Forest management demonstrations, under industrial, investment, institutional, municipal, or State ownership, totaled 22 at the end of the year and involved more than 187,000 acres. After 5 years, an outstanding example of these—Hassell and Hughes Lumber Co., Wayne County, Tenn.—had increased its employment from 80 to 130; in 1948 it produced 1,700,000 board-feet more than in 1947, a total of nearly 5,500,000, while its forest stock was increasing under sustained yield management. In initiating its management plan, the company turned to manufacture of small dimension stock from low-quality hardwoods, thereby improving the forests by taking out cull trees and leaving high-quality pines and hardwoods to mature.

Timber operators can probably influence forest resource development more than any other single group. A recent survey showed that at least 1,200 operators have now made one or more cuttings of selectively marked timber, where 15 years ago very few would consider buying timber except "by the boundary." The A. L. Dyer demonstration established on 200,000 acres of forest land in north Georgia is an example. It was based on a survey showing that the pine in the three-county area in which Dyer bought timber would be exhausted in 10 years if cutting of small trees continued; on the

other hand, if cutting were confined to pine of no less than 12 inches diameter and hardwood of no less than 14 inches, the area would produce 16,000,000 board feet annually with a potential production four times as great. Dyer is presently encouraging the trend in sustained-yield forestry by paying $45 a thousand board feet for logs over 13 inches in diameter and only $25 a thousand for logs under that diameter.

Forest Research and Experimentation

A wide range of research, surveys, and experiments is carried on by TVA in cooperation with other agencies to discover new facts which will encourage better management of the forest resource and better use of forest products. TVA and representatives of the United States Southern Forest Experiment Station, for example, are engaged in a survey of the operations of small sawmills, typical of the 3,700 in the Valley which each produce less than a million board-feet a year yet collectively account for three-quarters of the total Valley lumber production.

The type of facts which this survey is expected to reveal is demonstrated by a study in a Georgia sawmill of the advantage of sawing large logs rather than small. The study showed that logs over 9 inches in diameter yielded 62 percent more lumber per man-hour and 85 percent higher gross lumber value than smaller logs.

At the close of the year, TVA was constructing a wood hydrolysis pilot plant at Muscle Shoals to investigate a process for converting wood wastes and low quality cordwood into molasses which, like other sugars, can be made into acetic acid, and alcohol and used to produce yeast. The project was undertaken at the suggestion of, and in cooperation with, the United States Forest Products Laboratory. The process, an adaptation of an uneconomic German method, was developed by the Laboratory and tried in a full-scale alcohol plant in Oregon. The Laboratory is continuing its research in Oregon on conifers; the TVA research will be directed toward using hardwood species. Possibilities of wood molasses for stock feeding will be investigated by Valley agricultural experiment stations.

TVA, five State agricultural experiment stations (Alabama, Georgia, Mississippi, Tennessee, and Virginia), the United States Forest Service, and three large chemical companies are cooperating in a project to develop methods of applying preservative to nondurable pine and low-quality hardwood species to enable their use as fence posts. There is a shortage of durable woods for this purpose, while at the same time the demand for fencing is increasing due to expansion of livestock enterprises.

An experimental electric dry kiln for drying lumber was placed in operation. With a gross capacity of 3,500 board feet, the small kiln

offers promise of encouraging more local processing by small woodworking shops in the region. It was built by Stair Technical High School, Knoxville, Tenn., with the help of TVA and the United States Forest Products Laboratory.

Typical of other projects were test plantings to determine the best species for reforesting certain eroded lands, of varieties of northern pecans suitable for the Valley, and of varieties of walnut trees. State forestry and agricultural experiment agencies cooperate in such tests.

Reforestation

Nearly 4,500 landowners planted more than 15,000,000 seedlings from TVA nurseries on 13,900 acres of land during the year. Tishomingo County, Miss., landowners set a record by planting 1,250,000 trees during the year. TVA nursery production has been increased each year since the end of the war to keep pace with the demands of landowners interested in reforesting eroded soils and putting idle lands to work. Before the war, approximately 25,000,000 trees were being planted annually, mostly by the CCC and largely on public lands.

Facts Made Known

TVA data on forest subjects are disseminated as widely as possible for the benefit of people working with forest resources. During the year, forest industries were assisted with raw material, processing, and marketing problems, and data on potential plant sites were given to a number of concerns. Requests for information came from Federal, State, and private agencies, and from numerous individuals.

Minerals Investigations

Through the services of a small staff which cooperates widely with State agencies, TVA carries on regional minerals investigations intended to help the people of the Valley develop and use their mineral resources and to help solve their mining and processing problems in the interest of the development of local industries.

Field studies to locate and map mineral deposits are conducted as part of the activities. Cooperative research is carried on at the North Carolina State College Minerals Research Laboratory at Asheville, N. C., at the laboratories of Clemson College, S. C., and at the United States Bureau of Mines laboratory at Norris, Tenn. Facilities at Muscle Shoals are used in some projects. Mineral producers and owners of deposits are encouraged to make use of the research findings and are given individual assistance through identification of mineral and ore samples, field examinations to determine geology of deposits, and discussions of mining and milling problems.

For example, exploratory tests by TVA and Clemson College during 1948 indicated that sillimanite, of which large deposits have been

discovered in North Carolina, South Carolina, and Georgia, can be used as a substitute for imported Indian kyanite in the manufacture of superduty refractories and porcelain materials. Indian kyanite is increasingly hard to obtain.

During the last fiscal year, TVA and cooperating agencies have undertaken investigations to determine the extent and quality of deposits, to provide concentrates of sillimanite ore for laboratory research, and to build up a body of facts about sillimanite through laboratory research. Detailed study of some of the deposits are to be carried on. Large samples of the ore were processed at Muscle Shoals during the last year and coarse sillimanite concentrates provided to the Bureau of Mines electrotechnical laboratory at Norris for testing, and fine ground acid-leached sillimanite furnished Clemson College. At Asheville, good progress was made in improving methods of concentration. The electrotechnical laboratory is conducting research on superduty refractories.

Additional mica deposits, practically trebling the known deposits, were found in South Carolina. The Funkhouser Co. recently completed a processing plant near Hartwell, Ga., for the ultimate production of 9,000 tons of finished mica for use in the roofing trade. A continuous method of wet-grinding mica, developed by TVA, the Asheville Minerals Laboratory, and the English Mica Co. has recently been put into large-scale operation by the company. Several other mica producers were assisted by the TVA during the year.

The Harris Clay Co. and the Spruce Pine Mining Co. both opened new mines in halloysite deposits discovered and brought to their attention by TVA and State geologists. This material adds to the whiteness of fired ware.

Investigations also were made in connection with asbestos deposits, quartzites, and vein-type quartz in North Carolina, strip coal mines in Tennessee, and shales in several localities for processing into lightweight concrete aggregate. Extensive laboratory tests of sintering methods for expanding shales to make lightweight aggregates were carried on in cooperation with private companies. The methods developed in the work are being applied by commercial concerns to make lighter and more economical substitutes for the heavier sand, gravel, or crushed rock normally used in concrete.

Ilmenite from North Carolina was smelted in an electric furnace to produce a titania-rich slag for pigment extraction. This work was done in an effort to develop methods of processing domestic ores into pigment.

Thus, by bringing the facts about their resources to the attention of the people of the Valley, the TVA is contributing to the economic activity of the region and to the welfare of those who live there.

IV. More Power for More People

The number of consumers served with TVA power by municipal and cooperative systems increased from 851,000 to 985,000 during the year. Less than 1 month after the close of the year the number of consumers served exceeded a million. Individual consumers used more power in their homes, farms, and businesses than ever before. As it has every year since the end of the war, the use of electricity in the Tennessee Valley region during the fiscal year 1949 grew more rapidly than in the Nation as a whole.

The greater use of electricity in the area is a reflection of the progress the region is making in the more effective use of its resources. It is a reflection of the increasing number of jobs in industry and in trades and services and of the increasing productivity of agriculture.

The prospect at the close of the year was for continued growth in economic activity and in the use of electricity, making it imperative that TVA continue to add generating capacity and transmission facilities. During the year, TVA's hydrogenerating capacity was increased in the net amount of 144,000 kilowatts; in addition, 36,000 kilowatts were placed in service at the United States Corps of Engineers' Dale Hollow Dam which is operated in coordination with the TVA system. Construction was started on the 375,000-kilowatt steam plant at New Johnsonville, Tenn. With this plant plus the additional hydro installations already planned or in progress, there was under way an expansion of 1,200,000 kilowatts in the generating capacity of this region.

This additional capacity will be completed in 1952. Thereafter, the increasing demands for power will have to be met through additional capacity without which the region could not be assured the opportunity for full economic development.

Today almost four times as many people in the present TVA service area have electric service as had it in 1933. The average home uses nearly five times as much electricity as it did 16 years ago, but the limits of home use are far from being reached. Two-thirds of the farms in the region have electric service, compared with about 3 percent in 1933, and plans call for the construction of rural lines in the next few years which will make service available to the remaining third. While use of electricity on the farm has increased greatly.

the full value of this new "hired hand" is only beginning to be realized. It is true, too, that the region has experienced a very rapid industrial development, but it still has a long way to go to reach the level of production justified by its resources. In all, the region used 10 times as much power in the last fiscal year as in the year TVA was established. But much more power will be needed as this area moves toward full stature as a productive unit in the Nation.

The Fiscal Year in Summary

In the fiscal year 1949, TVA generated 15,750,000,000 kilowatt-hours, an increase of 10 percent over the previous year. Power revenues amounted to $58,000,000, over $9,000,000 more than a year ago.

Net revenues from operations were about $21,500,000 and represented a return of 5 percent on the average net investment in power facilities, which includes working capital and an allocation to power of a portion of the investment in multiple-purpose facilities. This rate of return was exceeded only by the 5½ percent earned in 1947. The annual return for the past 5 years has averaged 4.7 percent and from the beginning of TVA's operations it has averaged nearly 4 percent.

The municipal and cooperative systems bought 6,400,000,000 kilowatt-hours at wholesale from TVA, or 16 percent more than in the 1948 fiscal year. Their investment has grown to nearly $250,000,000. Their total operating revenues for the year amounted to $71,000,000, and their net income was $13,900,000.

The locally-owned electric systems built 17,200 miles of rural line during the year, bringing service to 75,000 farms heretofore without the benefits of electricity. Altogether, the local distributors invested $56,000,000 in system extensions and improvements.

The average home in the TVA region used 2,762 kilowatt-hours, 70 percent above the 1,625 kilowatt-hours average for the Nation. Residential users of TVA power purchased an estimated $100,000,000 worth of electrical appliances during the year.

Power Production

Good water conditions, together with additions to generating capacity, enabled TVA to markedly increase its power output. Rainfall averaged 58.7 inches over the watershed, compared with a normal of about 52 inches; run-off, too, was well above normal.

Total generation, including power produced at Aluminum Co. of America plants for which TVA directs the storage and release of water, and one plant on the Cumberland River (described below), was 15,734,764,000 kilowatt-hours. Peak hourly demand of the area served

by TVA was 2,419,900 kilowatts, or 285,000 kilowatts greater than the year before. The total peak hourly demand on the system, including deliveries to utility systems outside the TVA service area was 2,666,000 kilowatts, as compared with 2,457,500 kilowatts in the fiscal year 1948.

At the close of the fiscal year, with the reservoirs 85 percent full, TVA had an estimated 4,800,000,000 kilowatt-hours in storage—more than the system had ever had in storage before—but 1 month later the energy in storage increased to an estimated 5,350,000,000 kilowatt-hours before draw-down of the reservoirs began.

Source and Disposition of Power

Hydroelectric plants of the integrated system produced 13,285,649,000 kilowatt-hours during the fiscal year, an increase of 1,666,945,000 kilowatt-hours over hydro production in the 1948 fiscal year. TVA steam plants were required to produce 2,449,115,000 kilowatt-hours, slightly less than in the previous year. In addition, TVA purchased 234,750,000 kilowatt-hours from interconnected systems and received 1,166,827,000 kilowatt-hours in interchange. Power obtained from all sources totaled 17,136,341,000 kilowatt-hours.

Sales of power to the 144 municipal and cooperative distribution systems, Federal agencies, industrial plants, and other utility systems accounted for 13,614,194,000 kilowatt-hours. The Aluminum Co. of America received 1,730,167,000 kilowatt-hours in exchange for its own output and capacity contributions under the agreement by which TVA directs operation of its dams as a part of the system. A total of 950,818,000 kilowatt-hours was delivered to other systems as interchange. The remaining 841,162,000 kilowatt-hours represented system use and transmission losses.

Fuel Plant Generation

In the fiscal year 1949, approximately 16 percent of the system generation was produced at steam plants. The TVA system is primarily hydro-electric, but steam-electric plants are used to supplement hydro generation during periods of low streamflow. The amount of primary power—power which can be produced 100 percent of the time—is limited, in a strictly hydroelectric system, to the power which can be produced during the period of lowest stream flow. The additional power which can be produced during periods of higher flows is called secondary, or interruptible, power. This latter type of power can be sold, but because of its limited availability, it must be sold at a lower price than primary power. The use of steam plants to supplement hydro generation during periods of low flow increases the amount of firm power which the system is able to produce; the net effect, therefore, is to convert low-value secondary power into primary power,

which has a relatively higher value. This is the procedure which is generally termed "firming up" secondary power.

The TVA steam plants consumed 1,348,000 tons of coal during the year, an amount equivalent to a year's production for 800 miners working a 5-day week. Average coal consumption was 1.17 pounds per kilowatt-hours produced, as compared with 1.30 pounds per kilowatt-hour for the entire electric industry. The average at Watts Bar steam station was 0.92 pound per kilowatt-hour. Cost of coal consumed averaged $5.97 per ton, which was about the same as last year.

Generating Capacity Expanded

For the first time since the end of the war, the TVA was able to make substantial additions to its generating capacity as projects and units which have been under construction were placed in operation. During the year, seven units with a combined capacity of 190,800 kilowatts were placed in service. In comparison, the net increase in the system installed capacity between June 30, 1945, and June 30, 1948, was only 52,500 kilowatts.

The major new units included two 32,400-kilowatt generators at Wheeler Dam, two 32,000-kilowatt units at Fort Loudoun, one 26,000-kilowatt unit at Douglas, and two 18,000-kilowatt units at the Army Engineers' Dale Hollow Dam. The installed capacity of the entire system at the year end was 2,747,092 kilowatts.

On April 14, 1949, a 10,500-kilowatt generating unit at Ocoee No. 2 hydro plant went out of control while an attempt was being made to put it on the line. The unit reached an excessive speed and flew apart, destroying the generator and doing considerable damage to the turbine, powerhouse structure, and other equipment. The other unit at this plant was returned to service within a month of the accident and work has been started on the replacement of the damaged unit.

Power from Cumberland River Dams

Under an agreement with the Department of the Interior, which has the responsibility for disposing of power from all projects built by the Corps of Engineers of the Army, TVA will purchase the full output of three dams which the Army Engineers are constructing on the Cumberland River watershed. TVA will market this power to its customers, which already include municipalities and cooperatives serving about 70 percent of the Cumberland River basin.

A memorandum of understanding between TVA and the Army Engineers provides for operation of the generating facilities at the dams by the United States Army Engineers in coordination with the TVA system. Subject to the primary requirements of flood control,

the dams will be operated to produce power in accordance with schedules established by TVA.

When power installations at the other two Cumberland River projects—Center Hill and Wolf Creek Dams—have been completed in 1952, the total capacity of the three plants will be 441,000 kilowatts, and the total annual output will average about 1,300,000,000 kilowatt-hours.

Additional Capacity on the Way

Additional capacity now being installed will bring the total by the end of 1952 to 3,959,160 kilowatts. The new capacity will include 390,000 kilowatts of hydro capacity at TVA dams, the Johnsonville steam plant, and 405,000 kilowatts at the Army dams on the Cumberland.

Under average year streamflow conditions the power-producing capacity of this projected system will be approximately 22,000,000,000 kilowatt-hours annually, or roughly 40 percent more than was generated in the past year. According to present estimates, this is the amount of power which will be needed to meet the requirements of the present service area in 1952.

Operating Costs Reduced

Several steps were taken during the year to effect economies in the operation of the growing power system. The 7,000 miles of major power transmission lines heretofore patrolled on foot—a laborious, expensive, and time-consuming process—are now patrolled almost exclusively by helicopter. The helicopter is operated by a two-man crew—a pilot and observer. The latter is equipped with a dictating machine with which to record observations and with radio equipment to keep the plane in close contact with maintenance headquarters. The entire transmission system can be patrolled every 2 months and experience to date indicates that the helicopter will cut patrolling costs at least in half.

The cost of maintaining transmission lines has been further reduced by the extensive use of mobile-radio equipment. This equipment makes it possible to materially shorten the time required for locating and repairing line faults, thus cutting the length of service interruptions. Radio communication has also been of great assistance in directing line crews in emergencies and ordering necessary repair materials from headquarters.

Mobile radiotelephone equipment was installed in 7 maintenance vehicles, bringing the total to 129; 16 fixed radio stations were added throughout the area, bringing the total to 21. Lightweight handie-talkie sets were used to expedite overhead line construction and main-

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tenance work. These sets were also used to communicate with fixed and mobile stations from aircraft engaged in inspection of transmission lines.

Experiments are being conducted in the use of chemicals for clearance of transmission line right-of-way, a costly job which has heretofore been done manually with axes, brush hooks, and similar equipment. Results of the trial program to date are promising, but further experience will be needed before a complete evaluation of the results can be made.

The 66,000-volt primary substation at Athens, Tenn., was placed under remote-control operation from the Cleveland substation, 25 miles away. The new arrangement will permit certain operating economies.

Transmission System Improved

Good progress was made in strengthening the transmission system and relieving some of the conditions of serious overload which had developed in certain sections as a result of rapid load growth since the end of the war. One of the big problems of the past several years—that of securing satisfactory deliveries of equipment—has been greatly alleviated.

Expenditures for power transmission and communication facilities for the fiscal year totaled $18,900,000, practically the same amount as last year.

A considerable amount of work was done in 1949 on the expansion of the primary transmission system—the 154,000-volt system which interconnects the main generating stations, transmits power to the principal load centers, and connects the TVA system with neighboring utilities. Much work was also done on the subtransmission system, operated at 44,000 and 66,000 volts, to provide additional capacity at the many points where power is delivered to the municipal and cooperative systems.

TVA constructed 423 circuit miles of transmission line during the year for operation at 44,000 volts or above. The Dale Hollow Dam of the United States Army Engineers was tied into the system by construction of a 66,000-volt line from the Summer Shade, Ky., substation, and work was virtually completed on the tie lines to Watauga Dam, where power production was commenced 2 months after the close of the fiscal year. With retirement of 124 circuit miles of line during the year, the net addition to the transmission system was 299 miles, bringing the total to nearly 7,000 circuit miles.

Twenty-six substations were built during the year and one was purchased, while 14 substations were retired. There were 305 substations in operation at the close of the year.

The following table shows the transmission lines in operation at the close of the year:

Circuit miles of transmission line—TVA system

By voltage classes		By States	
Voltage	Miles	State	Miles
Kilovolts			
154	2,490	Tennessee	4,549
110	641	Alabama	914
66	1,232	Mississippi	827
44	2,421	Kentucky	575
33	28	North Carolina	77
22		Georgia	24
12 and below	163	Virginia	9
Total	6,975	Total	6,975

The Returns From Power

The returns from the power made available by TVA through its multiple-purpose development of the Tennessee River take several forms. Some of the returns, real and substantial though they may be, do not lend themselves to precise measurement.

It would be impossible to place a dollars and cents value, for example, upon the conveniences and comforts which low-cost electricity makes possible. Likewise, one cannot measure precisely the part electricity plays in stimulating economic activity and resource development. But unquestionably, the Nation and the region obtain a return in the form of greater prosperity and productiveness. These are important objectives of a public development.

At the same time, the TVA power operations yield annually a substantial direct financial return. In the 1949 fiscal year, this return amounted to 5 percent on the net average power investment. Favorable streamflow conditions and heavy demands for power contributed to the high return, which has been exceeded but once, in 1947 when the return was 5½ percent.

How Earnings Are Used

The following condensed statement summarizes the financial results of TVA power operations in the last fiscal year and in the 16 years since TVA was created.

Most of the 1949 earnings were invested in new power facilities, increasing the Government's equity in the power system. Of the cash available from 1949 power operations, $30,800,000 (net income before depreciation expense of $9,900,000) plus the 1948 cash balance of $7,600,000, $27,700,000 was reinvested in power facilities, $2,500,000 was used to retire bonds, and $3,000,000 was paid into the Federal

Treasury under the provisions of section 26 of the TVA Act. The balance on hand June 30, 1949, was $5,200,000.

From 1933 to date, revenues from the sale of TVA power have amounted to $367,000,000; out-of-pocket expenses, including payments to States and counties in lieu of taxes and interest on bonds (less interest receipts), totaled $155,000,000, leaving a balance of $212,000,000 as the net amount of cash resulting from TVA's power operations. This latter amount is made up of $130,000,000 of net income—an average annual return of nearly 4 percent—plus $82,000,000 charged against income for depreciation and amortization of acquisition adjustments. The $212,000,000 has been used for the following purposes:

For bond retirement	$13,500,000
Paid to U. S. Treasury	26,000,000
Retained in the power business	172,500,000
Total	212,000,000

Whether proceeds from TVA's power operations are used for bond retirements, payments into the U. S. Treasury, or retained in the power business, the net effect is to increase the Government's equity in the TVA power system.

Local Distribution of TVA Power

The task of distributing TVA electricity to the ultimate consumer is handled by locally owned and managed municipal and cooperative electric systems. Pursuing in general an aggressive policy of expanding service to new consumers and of encouraging increased use of power by their consumers, these systems have practically doubled the use of electric power in the region since the end of the war.

By almost any measure, the fiscal year 1949 was the most successful that the distributors have experienced to date. Service was extended to more new power users and more rural lines were built than ever before in one year; average use per customer increased rapidly; more power was sold than ever before; both gross revenues and net income were much higher.

At the end of the year, 144 municipal and cooperative systems were distributing power at TVA rates, an increase of four systems during the year. Two municipal systems—Morristown and Tullahoma, Tenn.—commenced operations under standard TVA contracts during the year. Morristown had previously been receiving TVA power in reimbursement for the city's steam plant, which had to be abandoned when Cherokee Dam was constructed. Tullahoma had been obtaining wholesale power under service arrangements which TVA had assumed from the Tennessee Electric Power Co. when that company was acquired in 1939. Both systems have long been munici-

pally owned. Two cooperatives also commenced purchase of wholesale power from TVA. One of these, the Powell Valley Electric Cooperative, serves several counties in upper east Tennessee and a small area in Virginia. The Tri-State Electric Cooperative acquired and commenced to operate distribution properties which TVA had owned since 1939, in an area roughly described as within a 20-mile radius of the point where the States of Tennessee, Georgia, and North Carolina meet. The four systems were serving about 14,400 consumers at the time they began operations under TVA standard contracts.

At the close of the fiscal year, the city of Cullman, Ala., was preparing to initiate TVA rates under a wholesale contract signed in 1946, and this was accomplished about 1 month later. TVA rates were also expected to be applied in Oak Ridge, the fifth largest city in Tennessee, during the fall of 1949. TVA power has been used in Oak Ridge since the town was built, but heretofore the Atomic Energy Commission included the supply of electricity as part of the services covered by rent payments.

Electric Service Extended to 120,000 Consumers

The municipal and cooperative distributors extended service to 120,000 new consumers during the year; three-fourths of these new consumers were in rural areas.

The increasing tempo at which the use of TVA power has been growing since the end of the war is indicated in the following table:

Fiscal year	Number of consumers (June)	Percent increase over 1945	Total kilowatt-hour sales	Percent increase over 1945
1945	580,400		3,023,645,000	
1946	668,800	15	3,381,878,000	12
1947	743,600	28	4,110,301,000	36
1948	851,400	47	4,966,942,000	64
1949	984,600	70	5,765,680,000	91

A favorable aspect of the operations of the distributors is the fact that the residential use of electricity has been growing more rapidly than other classes of use. Because residential consumption does not decrease during periods of business recession, it contributes to the financial stability of the systems. In the fiscal year 1949, sales to residential consumers accounted for 48 percent of the total revenues received by the distributors, as compared with 41 percent 4 years ago.

The following table gives the details of distribution of power among the various classes of consumers during the fiscal year:

Retail distribution of electricity at TVA resale rates—Municipalities and Cooperatives, fiscal year 1949

	Consumers		Energy		Revenue from sales	
	Number June 1949	Increase over 1948	Kilowatt-hours	Increase over 1948	Amount	Increase over 1948
		Percent		*Percent*		*Percent*
Residential	850,241	17	2,188,592,000	28	$33,679,470	25
Commercial and industrial:						
Under 50 kilowatts	130,665	8	1,000,055,000	12	16,981,253	12
Over 50 kilowatts	2,999	10	2,532,926,000	9	18,219,610	11
Street lighting	704	8	44,107,000	15	992,304	12
Total	984,609	16	5,765,680,000	16	69,872,637	18

Low Rates—Greater Use—More Revenues

The TVA Act directs the establishment of rates which are to be as low as possible but which shall bring in sufficient revenues to cover all the costs of generation, transmission, and distribution and liquidate the investment in power facilities.

In the development of these rates, two courses lay open. One was to follow the conventional theory of rate-making and base the rates on the prevailing levels of use. For residential service this averaged about 600 kilowatt-hours per consumer annually in both the TVA region and the Nation. Rates designed for this level of use would have been somewhat lower than the prevailing rates which averaged about 6 cents per kilowatt-hour and further reductions could have been made as the consumers increased their use of electricity and "earned" the lower rates.

The alternative was to follow the pricing procedure which has sometimes been used in other mass-production fields—that of reducing the price drastically on the premise that the lower price would stimulate greatly increased use, which in turn would provide revenues sufficient to cover all costs. This was the course adopted. Although the introduction of such low rates over a wide area may have appeared hazardous in 1933, the successful results achieved in the distribution of TVA power has dispelled any doubts as to its wisdom.

The extent to which this area has outstripped the Nation in the development of greater residential use is indicated in the following table:

Fiscal year	Average annual use		Average kilowatt-hour price		Average annual bill	
	TVA area	United States	TVA area	United States	TVA area	United States
			Cents	*Cents*		
1933	[1] 600	600	[1] 5.83	5.52	[1] $35.00	$33.12
1940	1,331	924	2.15	4.92	28.62	36.22
1945	1,726	1,186	1.88	3.47	32.46	41.15
1947	2,197	1,385	1.66	3.14	36.51	43.49
1949	2,762	1,625	1.54	2.98	42.50	48.43
Percent change, 1933-49	360.3	170.8	−73.6	−46.0	21.4	46.2

[1] Estimated.

Over the past 4 years, from 1945 to 1949, the average residential consumer in the TVA area has increased his use of electricity by more than 250 kilowatt-hours each year. In the Nation, the annual increase has been about 110 kilowatt-hours per year. It is conservatively estimated that the consumers in the TVA area are saving $33,000,000 a year in comparison with the cost of the same amount of electricity under the average of the rate schedules prevailing in the Nation.

Rural Service Expands Rapidly

Expansion of rural service progressed at a remarkable rate during the fiscal year. The municipal and cooperative systems built 17,200 miles of rural lines during the year, 50 percent more than the year before. They connected 92,000 rural consumers, of whom about 75,000 were farmers.

At the end of the year about 66 percent of all the farms in the TVA power service area had electric service. This compared with about 3 percent in 1933. According to REA, 78.2 percent of all United States farms were electrified on June 30, 1949.

It has only been in the last 3 years that full opportunity has existed for rural electrification by the distributors of TVA power. From 1933 to 1939, the distribution of TVA power was throttled by lawsuits and injunctions. In 1939 and 1940, TVA and the municipal and cooperative distributors were finally able to acquire existing electric facilities, but the distributors had hardly had time to organize operations, rehabilitate the acquired facilities, and make their rural surveys before shortages of materials and manpower began to develop as a result of national defense measures and later of the war. The shortages continued for at least a year after the end of the war.

In the past 3 years the distributors have constructed nearly 35,000 miles of rural line and have added about 155,000 farm and 50,000 rural nonfarm consumers. By the end of the 1949 fiscal year, they were connecting as many farms every 60 days as had been reached by power lines in the same area in all the years up to 1933.

At the close of the year the distributors were operating 68,000 miles of rural line. Plans call for the construction over the next few years of 25,000 miles of new rural lines to serve an additional 135,000 consumers.

Financing Improvements and Expansions

During the fiscal year the distributors invested $56,000,000 in distribution system improvements. Approximately one-fourth of this amount came from electric operations.

The balance of the improvement program was financed by $41,000,000 in new borrowings, of which $26,000,000 came from REA and $15,000,000 in new bonds sold to the general public. The weighted average interest rate on all new securities issued, other than REA loans, was 2.23 percent. At the end of the fiscal year, the distributors had a capital investment of $236,000,000. Of this, $73,000,000 represented accumulated earnings, $26,000,000 was provided by capital contributions, and $137,000,000 was secured from borrowings; loans from REA totaled $74,000,000 and bonds outstanding in the hands of the public totaled $63,000,000.

Electrical Development

Education and technical assistance are necessary if full and effective use of electricity is to be achieved. This is particularly true in an area where service is being extended to a great many people who have never used electricity before. To acquaint these new consumers with the many ways in which electricity can be used and to assist the older consumers with their electrical problems, TVA and a number of the local distributors have joined in a comprehensive electrical development program. This program, which is financed by the distributors and TVA was started July 1, 1947, and at the present time 107 of the distributors, serving 435,000 consumers, are participating. In this activity, TVA maintains a staff of specialists in the various applications of electricity—lighting, cooking, refrigeration, air conditioning, heating, and a variety of farm and industrial uses. The services of this staff are available to the participating systems.

The best measures of the effectiveness of this electrical development program are to be found in the growth in number of consumers served and the satisfactions which are being provided through effective increased use of electricity by all consumers, old and new. The extent of the increased use of electricity has already been mentioned. Among residential consumers there is another indicator—volume of appliance sales—of the growing number of services which electricity performs in the homes of the Tennessee Valley. According to Electrical Merchandising of January 1949, residential consumers in Tennessee, making up 1.7 percent of the residential consumers in the Nation, purchased 2.16 percent of the electric refrigerators, 4.67 percent of the electric ranges, and 3.80 percent of the electric water heaters sold in the Nation during the calendar year 1948. In 1948, it is conservatively estimated, consumers throughout the TVA power-service area bought $100,000,000 worth of electrical appliances.

Financial Results Are Good

The total operating revenues of the municipal and cooperative electric systems in the fiscal year 1949 amounted to almost $71,000,000. Combined net income amounted to nearly $14,000,000 and, as in the previous year, represented about 20 percent of the revenues.

Following are the consolidated income account and the balance sheet for the 144 TVA power distributors:

Combined financial statements, fiscal year 1949—94 municipal and 50 cooperative distributors of TVA power

BALANCE SHEET JUNE 30, 1949

	Totals	Municipalities	Cooperatives
ASSETS			
Electric plant at depreciated cost:			
Electric plant in service	$242,456,396	$149,362,133	$93,094,263
Less: Reserve for depreciation	47,408,066	34,422,118	12,985,948
	195,048,330	114,940,015	80,108,315
Unamortized acquisition adjustments	8,877,422	8,529,506	347,916
	203,925,752	123,469,521	80,456,231
Investments (at cost) and special funds	22,122,590	18,576,105	3,546,485
Cash for general use	6,306,710	3,870,843	2,435,867
Other assets	17,192,420	9,925,778	7,266,642
Total assets	249,547,472	155,842,247	93,705,225
LIABILITIES			
Capital:			
Investment of municipalities	1,069,896	1,069,896	----------
Memberships of cooperatives	2,893,148	----------	2,893,148
Received from consumers for retirement of debt	12,396,939	2,397,507	9,999,432
Grants from Federal Agencies	8,972,806	8,488,948	483,858
Other capital contributions	640,354	395,768	244,586
	25,973,143	12,352,119	13,621,024
Long term debt:			
Rural Electrification Administration	74,389,568	3,658,388	70,731,180
Bonds held by public	62,865,820	62,811,682	54,138
	137,255,388	66,470,070	70,785,318
Current liabilities	13,795,830	10,076,319	3,719,511
Accumulated earnings (see below)	72,523,111	66,943,739	5,579,372
Total liabilities	249,547,472	155,842,247	93,705,225

Statement of income and accumulated earnings, year ended June 30, 1949, and 5-year summary

	Totals	Municipalities	Cooperatives	Combined fiscal years 1945–49
Operating revenue	$70,864,155	$56,559,464	$14,304,691	$264,005,866
Operating expense:				
Purchased power	27,181,395	22,110,235	5,071,160	100,266,084
Distribution	7,786,353	6,018,544	1,767,809	28,388,572
Consumers' accounting and collecting	2,995,400	2,020,021	975,379	10,711,976
Sales promotion	937,434	821,508	115,926	3,109,410
Administrative and general	3,950,956	2,837,954	1,113,002	14,015,566
	42,851,538	33,808,262	9,043,276	156,491,608
Taxes and tax equivalents	3,017,811	2,713,269	304,542	12,434,287
Depreciation	6,788,701	4,376,960	2,411,741	24,121,804
	52,658,050	40,898,491	11,759,559	193,047,699
Net revenue from operations	18,206,105	15,660,973	2,545,132	70,958,167
Other deductions:				
Interest and debt expense	2,488,529	1,468,366	1,020,163	10,589,648
Amortization of acquisition adjustments	1,861,183	1,790,380	70,803	9,192,689
Extraordinary items [1]	83,565	101,057	[2] 17,492	396,879
Interest earned and other income	[2] 164,876	[2] 157,726	[2] 7,150	[2] 929,578
	4,268,401	3,202,077	1,066,324	19,249,638
Net earnings	13,937,704	12,458,896	1,478,808	51,708,529
Add: Earnings accumulated to June 30, 1948	58,585,407	54,484,843	4,100,564	----------
Accumulated earnings at June 30, 1949 (see balance sheet)	72,523,111	66,943,739	5,579,372	----------

[1] Consists of consumers' dividends, accelerated amortization of acquisition adjustments, cost of refinancing, gain or loss on operation of systems not supplied by TVA, and miscellaneous items.
[2] Deficit.

V. Personnel and Management

The number of TVA employees decreased by approximately 2,000 during the fiscal year, from 15,223 on June 30, 1948, to 13,174 on June 30, 1949.

About three-quarters of the decrease was in engineering and construction forces. TVA had about 880 fewer persons employed at the Upper Holston projects—Watauga and South Holston dams—at the end of the year than at the beginning, and there was a nearly equal drop in the number of persons employed in power engineering and construction.

Other decreases occurred at Fort Loudoun Dam after new generating units were placed in operation and at Hales Bar, where improvements to the dam were completed. At the same time, commencement of construction of the Johnsonville steam-generating station resulted in employment of 452 persons.

Training Activities

TVA believes that a chief function of management is to create an environment in which every employee will be alert to opportunities for doing his particular job more effectively. The TVA Board follows a policy of broad and liberal delegation of responsibility all the way down the line, and all TVA employees are encouraged to think about their jobs rather than merely to carry out assigned tasks. Great emphasis is placed on training.

At the close of the year, 1,305 of TVA's employees were participating in the employee-training program. There were 38 students in a training course for hydroelectric plant operations and 29 in a similar course for steam-plant operators. These groups were the largest in any year since 1944.

During the year also, the first group of eight electrical engineering trainees completed a 2-year schedule of work assignments in various phases of TVA power operations, and all were promoted to regular jobs. Fourteen 1949 college graduates were offered opportunities to enter into a continuation of this training program.

Of TVA's total employees, about 44.9 percent were veterans. As of June 30, 1949, 277 TVA employee veterans were in training under Public Laws 16 and 346. Of these, 19 were disabled veterans. Most of

the veterans were in the apprenticeship training programs. Five States had approved TVA as a training agency for veterans under Public Laws 16 and 346.

Labor Relations

Work in the area of labor relations continues to receive careful attention of TVA management. During the year, a report entitled "Labor-Management Relations in TVA" (Senate Report No. 372, 81st Cong., 1st sess.) was issued by the Joint Committee on Labor-Management Relations of the Congress of the United States. The foreword to the report, by the chairman of the committee, reads in part as follows:

> Far too much time has been spent on labor-management conflicts. Far too little attention has been paid to those situations in which the relationship between labor and management has been characterized by harmony and productivity. If we are to promote harmonious relationships between management and labor, it seems to me that we should study those situations in which harmony has been the rule rather than the exception. I am pleased to release to the public this report on how management and labor in the great Tennessee Valley Authority projects have learned to work together to their mutual satisfaction and in the interest of the people of these United States.

The TVA program of employee-management relations provides channels for employee expression of judgment and for resolution of grievances which develop on the job. Innumerable inefficiencies can result from unresolved grievances and from resentment against what the employee may consider to be arbitrary methods of developing and promulgating policies and procedures. These inefficiencies are almost impossible to locate and rectify by normal methods of administrative analysis. Their cure is a positive program of democratic labor-management relations.

Negotiations on Wage Rates

Under the TVA Act, TVA is required to pay the prevailing wage rates in the region. These rates are determined in negotiations between management and the unions on the basis of data collected from other employers and the unions. As a result of this determination the fourteenth annual wage conference between TVA and the Tennessee Valley Trades and Labor Council, representing 15 craft unions in the region, resulted in an over-all wage increase of approximately 12.2 percent for the classifications involved. The new rates became effective December 26, 1948.

Negotiations were also held with the International Association of Bridge, Structural, and Ornamental Iron Workers, which is not a member of the Tennessee Valley Trades and Labor Council. In addition to reaching agreement on changes in annual and hourly wage rates, the negotiations resulted in a memorandum of understanding

governing future negotiations along the lines of the agreement with the Tennessee Valley Trades and Labor Council.

Joint Cooperative Committees

Joint labor management cooperative committees continued to work effectively, with many suggestions being received from employees for improvements of one kind or another. Fourteen cooperative committees representing 3,906 employees and supervisors considered 557 suggestions during the fiscal year, of which 456 were accepted, 63 rejected, and 38 were pending. Of those accepted, 179 suggested ways to obtain greater efficiency; 96 with improvement of employment conditions; 101 with promoting safety and health; and 80 with improving morale.

Employee Safety

TVA's over-all safety program continued to be effective. The accident frequency rate declined to 5.6 accidents per million man-hours worked as compared with 8.5 the year before and 12.1 in the fiscal year 1947. The fiscal year 1949 rate was the lowest in TVA history. The severity rate was 1.69 days lost per thousand man-hours work, an increase from the year before when the index was 1.35. The increased rate, due chiefly to a single accident at a dam construction project, was still the second lowest in TVA experience.

TVA's safety record compares favorably with those of other organizations, according to the ratings of the National Safety Council. In a recent publication of the council showing frequency and severity rates for the calendar year 1948 and for the 3-year period for various types of construction units, TVA's construction organization ranked first seven times, second six times, and third five times. The National Safety Council awarded its Distinguished Service Safety Award to the Construction and Maintenance Branch working on the Upper Holston projects for having completed 1,385,471 man-hours without a disabling injury from December 1946 to August 1948. This award is given only to those organizations which have achieved an outstanding safety record, and was the first time the Council had made such an award to an organizational unit in TVA.

The power operations of TVA showed a slight increase in the accident frequency rate, from 6 to 6.5 per million man-hours, but still compared favorably with the 14.7 percent rate for power operations reported by the National Safety Council. The severity rate for the fiscal year 1948 was 1.62 days lost per thousand man-hours, compared with 1.32 the year before. Five TVA hydro plants, Hiwassee, Cherokee, Fort Loudoun, Douglas, and Kentucky, added another year to perfect records so far as accidents were concerned.

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Vehicular accident frequency was 1.26 accidents per 100,000 miles, about the same as in the previous year.

Procurement

The total dollar value of TVA purchases during the year was $46,411,982. Of this amount, $39,271,661 represented manufactured or processed articles, $6,200,379 represented raw materials such as coal and coke, phosphate rock, cement, aggregate, fuel and illuminating oils, and $939,941 represented miscellaneous services such as truck and team hire, burning debris, rental of office space and equipment, etc. Of the total outlay for manufactured or processed articles, $10,005,856 was expended in the seven States of the Tennessee Valley region, while $29,265,806 was expended in other areas of the country.

Cost of procurement activities remained low, amounting to eighty-two hundredths of one percent of the value of commodities purchased.

Accounting, auditing, and budgeting procedures developed in TVA for fiscal reporting and control are based primarily upon practices followed by commercial and business enterprises. These procedures anticipated, to a considerable degree, recommendations advanced last year by the Commission on Organization of the Executive Branch of the Government.

Since its inception, TVA has submitted to the President and the Congress budget programs organized and justified previously in terms of functions, activities, and projects. Budget estimates and financial statements are based on a single system of cost accounts maintained on an accrual basis; all costs of a given activity, program or project, are reported at a single point; and, since 1938, a clear segregation has been made between current operating expenses and capital outlays. Commercial type cost accounting provides all levels of management with current information to relate expenditures to accomplishments, and the functional budget, centering attention on objectives, performance, and over-all costs, not only makes for a clearer understanding of the agency's program, but encourages cost consciousness in the execution of that program.

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